REPORT OF THE

NATIONAL COMMISSION ON AGRICULTURE

1976

PART VI

CROP PRODUCTION, SERICULTURE AND APICULTURE

GOVERNMENT OF INDIA

MINISTRY OF AGRICULTURE AND IRRIGATION

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PREFACE

The Report of the National Commission on Agriculture comprises 69 chapters and 15 parts. A complete list of chapters and parts is given in pages (iii) to (v). The Terms of Reference of the Commission and its composition are given in Part I—Chapter 1—Introduction.

This volume, entitled 'Crop Production—Sericulture and Apiculture', is Part VI of the Report and is divided into the following eight chapters :

20. Reorientation of Cropping System
21. Foodgrain Crops
22. Commercial Crops
23. Horticultural Crops
24. Plantation Crops
25. Fodder Crops
26. Sericulture
27. Apiculture

REPORT OF THE NATIONAL COMMISSION ON AGRICULTURE

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CROP PRODUCTION, SERICULTURE AND APICULTURE

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PART VI

CROP PRODUCTION, SERICULTURE AND APICULTURE

PREAMBLE

This volume primarily deals with crop production. The discussion on crop production is prefaced by a chapter on reorientation of cropping systems. Thereafter various aspects of production of 70 individual crops are discussed. As the raising of host plants poses many problems identical to other crops, consideration of sericulture forms a part of this volume. Honey bees play a vital role in the increased production from effective cross-pollination in insect-pollinated crops. The subject of Apiculture has been discussed from this angle and included in this volume.

2. The crops included are : foodgrains (cereals, millets, pulses); commercial crops (oilseeds, fibres, sugar crops, tobacco); vegetable (tubers, bulbs, miscellaneous, mushroom) and crops ancillary to vegetables which are used in fresh and/or dried form either as an accompaniment to vegetables or for seasoning (coriander, chillies, ginger, turmeric); ornamental, aromatic and medicinal plants; fruits and plantation crops; fodders. The Commission constituted Study Teams on several crops. Study Teams have listed various research problems. The broad nature of many of these problems has remained the same even after the passage of time, for example, breeding for earliness, drought resistance, spacing, requirements of fertilisers and resistance to or control of pests and diseases. The emphasis changes according to circumstances. The techniques and infrastructure needed to solve these problems are already available. These can be dealt with in the usual course. With the provision of a little more infrastructure quite a few could be solved with the existing knowhow. In fact, some of the problems are already included in the Fifth Plan programmes and many others could be fitted in successive five year plans. Our recommendations relate to those which are in accordance with the principles propounded in our Report for reaching the contemplated production standards.

3. It may be noted that the emphasis so far has been more on increasing the quantum of yield rather than quality through breeding except cotton in which the reverse has been true. The agronomic

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aspects have not been attended to fully in research programmes hitherto pursued. But when these are done potentialities will increase significantly. It is pertinent to note that the performance of many crops requires improvement in the region comprising Madhya Pradesh, Uttar Pradesh, Bihar and Orissa. The study presented in these chapters chiefly aims at providing an answer as to which crop should be grown in which parts on purely scientific considerations in order to maximise production. How far a particular crop could be accommodated in the most appropriate rainfall zone and the alterations involved in the existing cropping patterns will be considered separately. These important practical considerations are essential to lift the level of productivity significantly. The present study is one of the steps in the whole process.

4. Subject to the adjustments on a tally of rainfall and cropping patterns, it has been the endeavour in the crop chapters to indicate broadly how much area should be under a particular crop and how it should be distributed in various parts of the country based upon agroclimatic considerations. An attempt has also been made to indicate the extent to which the yield levels could be raised in the case of various crops purely on technical considerations. The genetic potential of the various existing varieties itself is 3 to 4 times higher than what is obtained today in cultivators' fields. The yields obtained in Government experimental farms, demonstration plots and *krishi pundits'* fields will be found to be still higher, 5 to 10 times even in exceptional cases. Despite these indications, the standards adopted by us are moderate usually ranging between 2 to 3 times the existing yields. It is only in the case of certain pulses like *urid* and *moong* that the expected standard has been made 4 to 6 times the existing level (15 quintals as against 2-1/2 to 4 quintals per hectare). Little attention has been devoted to pulses so far. Cultivators also just take to chance cultivation, often in mixed cropping. These pulses are greatly disease and pest ridden. If there is a good grain setting, these are harvested for grain, otherwise these are fed as fodder. We expect this state to change and, therefore, with due attention, there is no reason why there should not be a very substantial increase in their yields.

5. The crop chapters give the targets of yields, the actual realisation of which would depend upon various factors. Crops would have to be grown in appropriate places at appropriate times and with the required backing of inputs like irrigation, seed, fertilisers and manures, plant protection chemicals and the soil would be required to be worked to proper tilth by using appropriate implements and tools. All these factors are crucial to the attainment of the contemplated yield levels. We have, therefore, devoted a separate chapter

on each one of them to ensure the provision of optimal conditions for crop production.

6. The history of crop production on modern lines takes almost a uniform pattern in India. If the emphasis on individual crops has varied in the recent past, it was dictated by the priorities fixed by the East India Company and the successor Government. Then came a review by the Royal Commission on Agriculture (1928), whereafter the researches came to be oriented and financed by the Indian Council of Agricultural Research and commodity committees. The latter were wound up in 1965 and their responsibilities taken over by the ICAR on research side and the Ministry of Agriculture and Irrigation through development directorates on the development side. The states developed their directorates of agriculture and organised research under economic botanists and specialists in agricultural colleges or specially created sections. Then came the establishment of agricultural universities in the sixties, whereby the research responsibilities by and large were transferred to them at the State level. In order to effect coordination of the research problems between the Centre and the States or among the States, various all-India coordinated research projects came into being. In effect, these projects have gradually almost monopolised researches on crop production. As long as the broad structure of historical developments is the same as mentioned here, it is proposed not to repeat it under individual crops; only the most pertinent points will be touched upon wherever necessary.

7. There are various kinds of demand for agricultural commodities, for human and livestock consumption, industrial use and export. In addition, an allowance has also to be made for seed and wastage. These requirements are discussed in Chapter 10 on Demand Projections. These have been kept in view while arriving at the targets of area and production for 2000 AD in crop chapters. The usual source of area and yield statistics of various crops has been the publication of the Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, entitled Estimates of Area and Production of Principal Crops in India. If any other source has been utilised, it has been duly indicated. The following sets of averages have generally been used :

(i) 1965-66 to 1971-72—when the latest trends are not very different from the averages thus derived.

(ii) 1969-70 to 1971-72—when the latest trends are different from (i) or when it is difficult to build past statistics as in the case of many fruit and vegetable crops.

(iii) 1968-69 to 1970-71—whenever a districtwise reference has been made to yields or Relative Yield Index (RYI—local yield as per cent of all-India). When these

computations were started in the Commission, the 1968-69 to 1970-71 was the latest period for which districtwise data were available in the case of Punjab, Delhi, Uttar Pradesh, Madhya Pradesh, West Bengal, Arunachal Pradesh, Manipur, Tripura, Orissa, Andhra Pradesh, Kerala, Pondicherry, Goa, Daman & Diu, Dadra & Nagar Haveli, Andaman & Nicobar and Lakshadweep. In the case of Haryana, Rajasthan, Bihar, Assam (including Meghalaya and Mizoram), Maharashtra, Karnataka and Tamil Nadu, the period was 1967-68 to 1969-70. It was 1966-67 to 1968-69 for Himachal Pradesh and Gujarat and 1965-66 to 1967-68 for Jammu & Kashmir.

8. Wherever a statement is made about the area and production relating to 'existing position' or 'present position' in contrast to 2000 AD, it should be understood to pertain to 1971-72 or the averages for the period ending 1971-72, unless otherwise specified.

9. In keeping with the years of production statistics, the export figures have also usually been for the years ending with 1971-72, unless otherwise specified.

10. Wherever it has been necessary to give an idea of irrigated area, the data for 1969-70 has been quoted. This has been done in order to have uniformity with the State working papers on Rainfall and Cropping Patterns, prepared and presented separately. When the work relating to these was undertaken, the latest irrigation data supplied by the States were for 1969-70. In case of wheat and paddy, the irrigated area is the average of three years, viz., 1969-70 to 1971-72.

11. Some of the abbreviations used throughout in the crop chapters are explained below :

km	kilometre
m	metre
M	million
Kg	kilogram
q	quintal
ha	hectare
gm	gram

The vernacular names have usually been given in italics in this Report but italics have not been used in the crop chapters for words like kharif, rabi, jowar, bajra, ragi, etc. Italics have also been avoided in tabular statements.

12. A reference can be made to Chapter 14 on Rainfall and Cropping Patterns. In order to have an idea of all the 12 months' rainfall at a glance, the following code has been used therein :

Symbol	Rainfall interval cm per month
A	greater than 30
B	20-30
C	10-20
D	5-10
E	less than 10 in combination with A or B, otherwise less than 5 with C, D or E.

A numeral subscript to the symbols has been used to denote the number of months in which a particular amount of rainfall is received. The south-west monsoon months of June to September are indicated in the centre by brackets, the months February to May being arranged on its left side and October to January on the right. For example, D1 E3 (A2 B1 C1) C1 D3 would be an expression of the entire year's rainfall, which could be deciphered with the help of the above mentioned explanations. The same connotations have been used in the crop chapters whenever occasions have arisen to discuss rainfall.

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REORIENTATION OF CROPPING SYSTEM

1 INTRODUCTION

20.1.1 The most ancient system of cultivation seems to have been what is called shifting cultivation which, survives in many parts of the world, including India, among primitive people. In this country we find it practised in the forests of the central plateau and in the heavy rainfall areas of the north-east and efforts are being made here to wean such people away from these systems which are harmful to the soil and vegetation. In the history of agriculture the shifting system gave way to the fallow system of cultivation. Later with the development of tools and implements to work the soil, the knowledge of use of animal dung as manure and the different ways of storing water for irrigation, the various field systems of cultivation appeared. Domestication of cattle and other farm animals had also progressed meanwhile and in course of time a pattern of mixed farming has developed through the ages which is practised by the Indian peasantry in general. The average farmer has a piece of land to raise his crops and a few heads of livestock and sometimes a few ducks, or hens for meeting his various needs. Another significant development over the ages in farming in India was the system of rotation of crops which, however, was developed on a scientific basis in England during the period 1730—1738.

20.1.2 Farming systems can be classified on the degree of commercialisation involved. In subsistence farms there is hardly any surplus for sale, as the products are mainly used for household consumption. Most small farms belong to this class. In bigger and partly commercialised farms cash crops are also raised and sold though such sales remain well below 50 per cent of total value of crops produced. In farms run on a regular commercial basis the sales of farm products constitute the major part of the gross returns.

20.1.3 The basic classification in which the above mentioned farming systems could be fitted would be (a) rainfed farming and (b) irrigated farming. The system of mixed farming will be found superimposed over these two basic systems in varying degrees all through

the country. Modern concepts and technology have only tried to systematise mixed farming practices which have been followed in India. The scope of mixed farming is going to get enlarged in future with more and more suburban farmers keeping a few milch cattle and poultry to supplement their income and Chapter 33 on Mixed Farming has been exclusively devoted to this aspect. Chapters 26 and 27 deal with Sericulture and Apiculture respectively; these activities are also being planned on a large scale and, therefore, would contribute to broaden the horizons of mixed farming in India.

20.1.4 Keeping intact the basic structure of farming applicable to the country's climatic, soil and sociological conditions, it could yet be improved through progressive orientation in the following manner :

(i) Farming has to be so readjusted that the crops could make the best use of rainfall in order to meet the water needs as only 84 Mha of gross cropped area would be in a position to be irrigated out of a total of 200 Mha even by 2000 AD.

(ii) Irrigation water has to be so expended that it could benefit the rainfed cropping during spells of deficient rainfall wherever possible i.e., the emphasis should be to make irrigation water supplement the contribution of rainfall to the greatest possible extent. Where reliance has to be solely on irrigation water, its utilization has to be maximised both by avoiding wastage and taking such crops which are most efficient users under the given set of conditions. Thus high water requiring and long duration crops could be fitted into the perennial type of irrigation but where water availability is restricted in time the crops taken should be those whose water requirements also correspond to these conditions.

(iii) Inefficient crops/varieties should give way to more efficient ones from the point of view of total production being assessed per unit of time and inputs consumed.

(iv) Uncontrolled grazing should be replaced by feeding cultivated fodders, for which the area under fodder crops has to increase and various kinds of fodders have to be cultivated.

(v) Short duration field crops have to give way to long duration crops like sugarcane, banana, plantations and fruit gardening in appropriate situations.

(vi) Single cropping has to be replaced by multiple cropping wherever possible.

(vii) Natural regeneration of soil fertility has to be supplemented by intensive manuring and fertilizer application.

(viii) Intensive plant protection measures should be adopted according to need.

(ix) Farm animal power should be supplemented by machine power according to exigencies in order to improve production standards and remove drudgery from operations.

20.1.5 There are separate chapters in our Report which devote exclusive attention to all important factors which have a bearing on the above mentioned objectives, viz., rainfall in relation to cropping patterns, irrigation and command area development, soil and moisture conservation, crops, animal husbandry, seeds, fertilizers and manures, plant protection chemicals, farm power and associated implements and machinery. An integrated and broad view of the role of these various factors in agriculture, and the farming systems most aptly suited to the country's conditions is attempted in this chapter.

2 RAINFED FARMING

20.2.1 The source of water for farming is mainly rain although in some parts snow and dew also contribute water for farming to a certain extent. Rainfall is variable all over the world. It is much more so under tropical conditions. Different places receive different quantities of total annual rainfall. In some regions, rainfall is restricted to a few days in a year as in Rajasthan, whereas it occurs practically throughout the year in the areas like Nicobar Islands. While the total quantity may be as much as 1100 cm as in Cherrapunjee in Assam, it may be even less than 10 cm as in some places in Rajasthan. In addition to differences in total rainfall from place to place, there is variation from year to year. Variation may be as much as hundred per cent in some places. Also, patterns of distribution within a year vary considerably from year to year. The analysis of rainfall patterns in various parts has been carried out in detail and based on rainfall patterns, 62 regions have been identified in the country. The cropping patterns in vogue have been analysed for each region. The details of cropping patterns and livestock patterns in different rainfall zones of the country have been given in Chapter 14.

20.2.2 Rainfall is one of the main climatic factors that affect the choice of crops and cultivation practices besides influencing the final yield. Farming system in any place is controlled or is determined to a great extent by the amount and distribution of rainfall. The soil and other natural environmental factors as also the socio-economic factors affect the cropping system in a place. In the areas where farming depends exclusively on rainfall, the most important determining

factor is the duration and the total rainfall. The period of rainfall in different areas may vary from 1 to 2 months in a year to 8 to 9 months. According to the total rainfall, the areas can be identified under four groups, viz., heavy rainfall areas, high medium rainfall areas, low medium rainfall areas and low rainfall areas.

Farming in Heavy Rainfall Areas

20.2.3 Heavy rainfall areas receive rainfall for three months at least at the rate of more than 30 cm per month during the rainy season, i.e., between June and September. In some areas rainfall amounting to 30 cm or more per month may occur for six months covering both pre-monsoon as well as post-monsoon periods. There are some areas where rainfall of a lesser magnitude occurs in pre-monsoon as well as post-monsoon periods. The rainy season may begin as early as March and extend beyond November. The heavy rainfall areas could, therefore, be sub-divided into three or four sub-zones. One zone can be that which receives rainfall only during the monsoon or rainy season, that is between June and September. In the second there is rainfall during pre-monsoon as well as post-monsoon periods. In the third zone in addition to the rainfall during rainy season substantial rainfall occurs in the pre-monsoon or post-monsoon periods also. The heavy rainfall areas occur mainly in the eastern zone consisting of Assam, West Bengal and other hilly States and along the west coast. These areas are also known as tropical rain forest areas.

20.2.4 Nature being more bountiful with regard to plant as well as animal products because of heavy rainfall, these areas of heavy rainfall are more congenial for the collection of natural products. Another reason why collecting stage continued for longer period in these areas is that natural vegetation is more vigorous. It is difficult to suppress natural vegetation. The means available in earlier times were also not adequate enough to remove the natural vegetation and grow the desired vegetation in their places. Then came the shifting cultivation which is even now commonly practised in heavy rainfall areas. Later, paddy crop was introduced and it was restricted mostly to valley portions. Gradually, however, paddy was extended to higher elevations also to the detriment of soil fertility levels. At later stages, plantation crops were introduced in elevated areas. Where population pressure kept on increasing and the need for growing various other field crops like maize, potato and other tuber crops was felt, these were also introduced in the elevated areas. Further, due to increase in population, more land was opened up for cultivation and many arable crops consisting mainly of root crops were introduced.

20.2.5 The cropping pattern in the above heavy rainfall areas shows the dominance of paddy all over. Tuber crops, plantation crops and some cereal crops like maize and ragi or other small millets also appear in between. Because of availability of plenty of grazing areas the animal population here is fairly high and they are a source of animal manure for use on cultivated fields.

20.2.6 The cropping system is mainly that of monocropping here though there is considerable scope for diversifying cropping. Dominance of paddy will naturally continue because of heavy rainfall; but ample scope exists in introducing crops before and after paddy especially in those areas where the rainy season extends for a longer period. In areas where there is good rainfall during March, April and May, it is possible to take one or the other pulse, fodder and vegetable crops and the same can be done even during post-monsoon period, where the rainfall extends over October and November. In some areas pulses are being taken even now, but it is being done to a limited extent. Attempts are being made to introduce cotton in Sunderbans of West Bengal. A number of green manure crops are being tried in some parts in the west coast. Various pulses and cereals also are being taken with advantage. Greengram and Bengalgram are being grown successfully. In recent years, hybrid jowar is being tried after paddy with great success in some parts of Karnataka. Taking of wheat with supplementary irrigation is becoming popular. Many vegetables also are being grown during this period. There is also scope for relay cropping. Examples of planting sugarcane before harvest of paddy or sowing of pulses or fodder crops before harvest of paddy are available. Where the temperature conditions are milder, it may be possible to take wheat or vegetable crops too as relay crops. The main drawback is the lack of a research organisation in these areas to study the existing cropping systems and to develop appropriate alternative cropping systems for such areas. Water resources are good in these areas. These resources should be put to full use mainly by diversifying the cropping systems so that the present linkage that is existing between paddy and poverty is broken.

20.2.7 In heavy rainfall areas rain water can be stored in the valleys which are usually deep, by constructing suitable weirlike structures. In some parts of the country, bridges are converted into weirs with gates for storage of water. Gates are kept open during rainy season when the flood water can flow without causing any damage to the land as well as to the structure. At the close of rainy season, the gates are lowered down and the water is held in valleys. The stored water is pumped and used for growing crops during post-monsoon period which facilitates the extension of crop growing season by at least 3 to 4 months. The structures can be constructed in

series and water held practically all along the valleys. This will go a long way in diversifying the cropping systems. There is dearth of vegetables and pulses in these areas. Water stored could be more advantageously used for raising these crops. These valleys remain dry after the rainy season. At present, attempts are being made to divert the flowing water to cover small areas under irrigation for a short period. If water is stored then the growing season can be extended further.

20.2.8 Another possibility in heavy rainfall areas, as far as paddy is concerned is of utilisation of underground water during rainy season itself. Prolonged droughts do occur here especially in the month of September when paddy is about to head out. At that time it is possible to tap underground water which is available in plenty and reduce the effects of droughts to a very great extent. A small shallow well can be dug in every plot and water pumped to save the crop from the effects of drought.

20.2.9 In hilly regions, cropping with cultivated or field crops may not be an advisable proposition. At present, because of population pressure, even high lands are being opened up and crops like maize, ragi, etc., are being grown. As stated earlier, shifting cultivation also is being practised on hill slopes. Growing of any cultivated crop on hill slopes even after adopting soil and water conservation measures like terracing is not an advisable practice as terraces do not remain in condition in spite of care taken to maintain them because of heavy rainfall. Field crops can be restricted to the valleys and the hill slopes put either under forest trees or plantation crops or grasses combined with trees. Trees grow very fast and yield useful products at a much faster rate as compared to low rainfall areas. Man-made forests can be raised with great advantage in such areas. Pineapple can be grown with advantage in all these heavy rainfall areas. Raw material for paper industry and other wood based industries can be developed equally well in these areas. It is, therefore, necessary to study the socio-economic possibilities of different cropping systems and mark out areas for man-made forests, for plantation and fruit crops and for grazing lands.

20.2.10 The other important aspects that will have to be kept in mind in developing appropriate cropping systems in hill slopes in heavy rainfall areas are with regard to transport, processing and marketing problems. Suitable transport facilities will have to be developed for quick transport of products along with suitable processing industries in the case of perishable commodities so that storage losses would be checked. A marketing system will have to be developed to ensure sale of products.

20.2.11 In heavy rainfall areas, there is the problem of holding

soil *in situ* and also maintaining soil fertility. The rains are torrential and, therefore, low lying areas are subjected to flooding and hilly slopes to considerable erosion. In Nature, such areas are protected by natural thick vegetation, grass and trees. When this natural vegetation is removed for growing field crops, the soil is subjected to deterioration physically as well as chemically. In heavy rainfall areas, leaching of soil nutrients is taking place continuously. It is only the deep rooted trees which can help in bringing back these leached out nutrients to the surface. Freshly opened soil appears to be fertile to start with. It deteriorates fast and yields come down within a few years. The physical condition of soil is lost quickly. The nutrients that are built up through long years are leached out very fast. It is therefore a problem how to maintain the soil fertility in these areas. If the hilly portions are put under grasses and trees or plantation crops combined with trees soil fertility can be maintained. But if they are opened and used for growing field crops, the problem of maintaining soil fertility as well as productivity becomes a serious one. Even in valleys the problem persists. It is for this reason that in heavy rainfall areas, where plantation crops like arecanut, pepper, cardamom are grown, some adjoining high lying forest area is also allotted to plantation owners so that they could use the leaf manure that becomes available for building up the fertility of plantation gardens. Now these adjoining areas are not having tree growth ; as a result no leaf manure is becoming available for use in plantations. Fertilisers are being used with some advantage, but the physical condition as well as the deficiency of minor elements like zinc, magnesium, etc., are limiting the production. Many physiological diseases have appeared in plantation crops in Kerala and other west coast areas. The problem, therefore, of maintaining soil fertility is a gigantic one in heavy rainfall areas. Studies should be carried out to pin-point the exact role that leaf manure and other organic manure can play in these areas. Suitable fertility maintenance programme will have to be developed by carrying out long range experiments.

20.2.12 In short, it can be said that heavy rainfall areas are quite well endowed with soil and water resources. In spite of this, some of these areas occupied by tribal people are the most backward in the country and their economic status could be improved by evolving farming systems suitable for adoption by them. System of paddy growing could be improved considerably. Mechanisation could be introduced to improve the drudgery in raising paddy wherever it is desired by farmers and where it does not lead to serious unemployment of agricultural labour. Better methods of raising seedlings of paddy could be developed. As against the existing practices, raising the seedlings elsewhere could be attempted using underground water

rather than depending on rainfall only. A lot of organic material is being burnt today in Konkan for raising seedlings through a wasteful practice known as *rabbing* which can be done away with.

20.2.13 There is possibility of raising tuber crops with great advantage. But cultivation of such crops should be encouraged only after developing suitable cultivation practices designed to maintain soil fertility. Many other tropical crops like sugarcane could be raised with advantage. Even in valley portions plantation crops would be better than paddy. At least some portions could be set aside for plantation crops instead of paddy.

20.2.14 The problem of pests, diseases and weeds is also gigantic one. Because of continuous rain it is difficult to control weeds. It is, therefore, necessary to develop suitable chemical and mechanical methods for controlling weeds. Pests and diseases are also serious because of continuous high humidity. Adopting chemical methods may become difficult because of continuous rain. It is, therefore, advantageous to develop appropriate pest management practices including the use of pest resistant varieties. Use of chemicals will have to be restricted.

20.2.15 The problem of labour is acute in these areas. Density of population is low in the hill regions compared to other areas. It is difficult in many cases to carry out the operations in time. The work required to be done is arduous and exhausting. The climatic condition itself is such that it is difficult to expect labour to put in long hours of work. The human as well as animal population is undernourished and weak. The deficiency of calcium, phosphorus and other nutrients in these areas reflect on human and animal health. The humid conditions prevailing practically throughout the year result in human as well as animal diseases. During recent years, however, the human disease problem has been reduced to a very great extent because of availability of new chemicals for controlling insects (vectors), that are responsible for transmitting some of the human diseases. Malnutrition, however, is yet persisting. Health measures will have to be taken, side by side with the development of agriculture. It is only then that it would be possible to get the maximum from the land in these areas.

20.2.16 Seeds deteriorate very fast in high rainfall areas. It has been shown that good sugarcane material brought from outside deteriorated within 2-3 years. Seed produced and stored in the same area, for later use will not be good. It is, therefore, necessary to raise the seed and planting material required for these areas elsewhere and then bring it in. Animals also deteriorate very fast in these areas. Those moved from low rainfall areas to heavy rainfall areas deteriorate mainly

because of the poor quality of fodder which is usually low in nutrients particularly calcium and phosphorus. It is, therefore, necessary to carry out intensive study with regard to production and supply of seeds as well as nutritious fodder for animals. There is probably scope for mechanisation. Suitable mechanical equipment will have to be developed both for cultivation of crops as well as for processing and drying of the produce.

Problem of Floods in Some Heavy Rainfall Areas

20.2.17 The areas prone to frequent devastating floods are the north-eastern districts of Bihar in Saharsa and Purnea and the Brahmaputra valley in Assam. By virtue of the geographical situation of these areas *vis-a-vis* the head catchments of rivers, it is difficult to control the floods through engineering methods. Hence, the farming strategy should be such as to think of escaping and/or enduring them. The Assam Agricultural University is thinking in terms of placing greater emphasis on cultivation during the flood-free periods. The worst period to be avoided is July-August although in some years the floods may occur as early as in the first week of June and as late as last week of September. Some of the steps already thought of on the basis of experimental trials are stated below :

(i) Rice varieties like CH-63 and Pusa 2-21 can be grown in the pre-flood period of February—May. A short duration rainfed crop of rice can be taken with varieties like RP 79-23. *Sali* paddy transplanted in July-August may be discouraged as it suffers most from floods. Yield of rice from post-flood crops is quite good but varieties chosen should be cold-tolerant and photo-insensitive.

(ii) Late jute crop may be discouraged as it suffers from floods and the early crop should be started even a little earlier than March. Wheat, mustard, pulses, peas and vegetables are some of the other crops whose cultivation can be encouraged in the flood-free period from September onwards.

20.2.18 We favour the above kind of approach and would strongly recommend that trials in this regard should be pursued on a priority basis both in Assam as well as Bihar to change the traditional order of cultivation by avoiding the flood-prone months of July and August for as many crops as possible. However, an alternative has to be kept for growing some kind of crops during these two months. There are some known varieties of rice which have the capacity to keep pace with the rising waters and can grow under deep water con-

ditions. In Assam, *bao*, the deep water rice, and *asra*, the shallow water rice are well-known. These varieties have a better chance of survival under flood conditions of different intensities.

Farming in Low Rainfall Areas

20.2.19 The condition of agriculture is quite precarious in the low rainfall areas where population pressure has also been building up steadily. Main effort in these areas has been towards developing irrigation facilities. The animal industry which was flourishing is facing serious problems in recent years. It is in the low rainfall areas that best breeds of animals can be found even today. The animals are good dual types, for draft as well as milk production. Sheep industry has developed quite well in these areas. The goat has been introduced lately to the disadvantage of the animal industry as a whole. There is however good scope for developing animal industry again as it existed in the past.

20.2.20 The low rainfall areas are found in high as well as low latitudes. The belt of low rainfall stretches right from Kashmir in the north down to Kanyakumari in the south. Although total rainfall in these areas varies between 250 and 750 mm per year, the spread is restricted to only about a few days in Rajasthan whereas it extends to about 6 months in the southern parts. In the northern part of the country all the rains fall between June to September with peaks in July and August. In the southern parts, however, rains start in some areas as early as April and extend up to November. In the southern most parts of the country, rains occur even in November/December as a consequential effect of north east monsoon. In the central portion the peak is in July and the other in September/October. In the southern most portion which is under the influence of north east monsoon, the peak is in November/December. The rainfall is highly variable in all these areas both in total quantity and also in distribution pattern. There is no certainty of anything, neither the total rainfall nor the extent of it during particular seasons. The one thing that is certain in the northern parts is the occurrence of fairly good rainfall from mid-July to mid-August. In the central parts, however, August rainfall is uncertain. In south central parts September/October rainfall is more reliable. In southern most portion November/December rain is certain as compared to practically no rainfall at all during the regular months, *i.e.*, from June to September.

20.2.21 Soils vary considerably in the low rainfall zones. In the north they are mostly alluvial. In the central part they vary from light gravelly to deep black soils and in the southern parts from

sandy loam to loams with small patches of black soil. These soils are subject to heavy erosion because of heavy intermittent showers during the period when the soil remains practically bare. In many parts, soils are impregnated with salts and in low lying patches alkaline and saline soils do occur. Medium and light soils are amenable to management, but these are more droughty because of low water holding capacity. Although difficult for management, black soils have high water holding capacity and are suitable for rabi cropping more than for kharif season cropping. One interesting feature of low rainfall areas is that there is good supply of underground water especially in the northern parts and there is a network of tanks in the southern parts.

20.2.22 The dominating crops in this zone are mainly millets, jowar and bajra in the north, jowar in central parts and ragi in the southern parts. Mixed cropping is very common. Pulses are grown mixed with cereals. More popular among the pulses grown during the kharif season are redgram, blackgram, horsegram and greengram. Wheat and rabi jowar are important rabi crops. Mixed cropping is common in rabi season too. Gram and safflower are often grown mixed with rabi jowar and wheat. Groundnut is another very important crop in this zone. There are a number of other oilseed crops—sosamo, niger, safflower, rape and mustard etc., which are grown commonly in this zone. The low rainfall areas are quite rich in the variety of crops grown. The cropping patterns also are such that no one crop dominates, unlike in the heavy rainfall areas where paddy dominates. All kinds of millets, oilseeds and pulses are grown in this zone. As a result, the cropping patterns are a mosaic of a number of crops. It is very clearly seen in Chapter 14 on Rainfall & Cropping Patterns that no crop covers more than 30 per cent of area in any particular zone. To form a cropping pattern, there has to be a combination of 4 to 5 crops. The main reason for this sort of cropping pattern appears to be the uncertain conditions that prevail in this zone with regard to rainfall. Farmers have to adjust their cropping system depending upon the season when the rains occur. In some years there may be early showers and in some other years there may be late showers. Crops have to be sown, depending upon the season when rains occur. If there are early showers, crops like jowar are taken. If there are late showers, preference is for bajra or various kinds of other millets.

20.2.23 Although at the outset the scope for changing the cropping systems may not appear bright, yet the possibilities would not be found wanting on a close examination. There are possibilities of introducing new crops. Cotton is being grown on large scale in some of these areas. The yields of this crop are quite low. Probably, it

would be necessary to reduce the area under cotton and introduce other crops that yield better than cotton. Long duration jowar varieties are taken during kharif season; probably these could be replaced with short duration varieties. In some of the areas it may be possible to change over from rabi cropping to kharif cropping. Some of the area under groundnut could be diverted to barley or safflower or even gram. The possibilities of changing crops as well as the cropping pattern are greater in the southern parts where the rainy season lasts for longer period and where there are two peaks of rainy periods. Recent studies have indicated the possibility of taking a catch crop before the main crop of ragi in the main ragi growing areas of the zone. It is also possible to advance the sowing dates for rabi crops. There are also indications that kharif crops could be started early provided land is prepared immediately after the harvest of the previous crop.

20.2.24 Studies have brought out very clearly that mixed cropping and relay cropping could be improved to a considerable extent, and new crops could be tried for relay as well as mixed cropping. In general, it can be said that some breakthrough is possible in cropping systems in low rainfall areas. The work that is still to be done on intensive scale with regard to cropping systems is in regard to possibilities of introducing fodder crops in rotation with field crops. It would be probably necessary to put the marginal lands and also erodable and eroded lands under grasses rather than under arable crops. It is also possible to introduce forage crops especially the forage legumes in rotation with field crops. Studies in this regard are wanting. The emphasis so far has been on arable cropping rather than introducing forage crops either in rotation or as leys. Forage crops have a definite place in these areas. They can receive and utilise the rain water whenever it becomes available. For field crops it has to be seasonal to get the maximum benefits. The cropping systems, therefore, are required to be worked out keeping this point in view. It will be only then that the animal wealth in these regions can be maintained and increased. As stated earlier, good breeds are available in low rainfall areas both of cattle as well as of sheep. The animal industry can be built up by adjusting the cropping systems to meet the needs of animals as well as human population. There are possibilities of taking forage crops before or after the main crop where rains occur for an extended period. It is also possible to take forage crops as mixed crops along with arable crops. Some studies have indicated such possibilities. Detailed intensive studies would throw more light with regard to this aspect of cropping system.

20.2.25 Owing to uncertain nature of rainfall in these regions, it is necessary to make arrangements to store water as and when it

is received and use it for irrigation during critical periods. The studies in recent years have indicated that it is possible to stabilise production in these areas by storing rain water in farm ponds and using it for irrigation during critical periods. It has been possible to improve cropping systems also wherever it has been possible to store water in farm ponds in this manner.

20.2.26 Soil erosion is a problem in low rainfall areas because of receipt of rain with high intensity in short periods. Soil and water conservation measures are required to be taken in an adequate manner. At present, it is difficult to adopt both soil and water conservation measures because of the nature of distribution of holdings. In major part of the country, land consolidation has not been done. In Chapter 68 on Consolidation of Holdings, it has been indicated that consolidation work has progressed satisfactorily only in few States. In other States, consolidation work is either lagging behind considerably or nothing has been done practically. It is a very urgent step that is required to be taken so that appropriate soil and water conservation measures could be adopted without any physical handicap. Because of narrow long strips of plots, it is practically impossible for any farmer to adopt contour cultivation or other measures that are to be taken on contour. It is only through land consolidation that this position could be improved. Contour bunding is being done on large scale in this area. Just putting physical check is not sufficient to bring about real benefits of soil and water conservation. The various aspects of contour bunding and other soil and water conservation measures have been discussed in Chapter 18 on Soil and Moisture Conservation. Here it is sufficient to point out that in low rainfall areas maximum improvement can be brought about only through adoption of improved soil and water conservation measures including the use of farm ponds for storing rain water for use during critical periods. Such improvements can be adopted only if physical limitations that exist are removed by adopting appropriate measures of land consolidation and intensifying contour bunding programmes.

20.2.27 Fertility status of soils in these areas is fairly good, but their organic matter content is very low. It is very difficult to build up organic matter content in this zone because of high temperatures and quick disintegration of organic matter. It is also difficult to add large quantities of organic matters to the soil in this region. The addition through roots is not much because of poor growth of plants. Even then, the possibilities of improving the organic matter content of the soils are available. Where cropping is done during rabi season it may be possible to broadcast seeds of green manure crops with the receipt of rain in the month of June and incorporate the green mate-

rial in top soil just by mixing with the help of disc harrow or ordinary tillers. This has shown to be beneficial in some of the black soil tracts. Application of superphosphate to green manure crop would further improve not only the green matter yield but also the nitrogen fixation. Such simple measures are available for improving organic matter content of the soils in these regions. More studies will be required to be carried out to identify appropriate natural vegetation which would help in preventing soil erosion and also in adding organic matter to soils. The work done in this regard is not sufficient and needs to be intensified. Forage crops if introduced in rotation with field crops as suggested earlier would also help in building up the organic matter content of the soil. Such possibilities are required to be studied in detail. It is only then it will be possible to improve the physical conditions of soils.

20.2.28 Improvement of physical conditions is very necessary to improve the water holding capacity of the soils. The soil storage capacity has to be built up by improving the infiltration capacity and the latter by improving the organic matter content of the soils. One has to be very cautious with regard to application of fertilisers in these areas. Heavy application of fertilisers as is done for irrigated crops is not possible for dry crops. Judicious use of fertilisers will have to be the rule which will include proper choice of fertilisers and time and method of application. Placement of fertilisers has an advantage over broadcast application. Unless fertilisers are placed at appropriate depths by using suitable implements, it will be difficult to get maximum benefit from fertilisers. Time of application also assumes importance because of limitation of water supply for crop growth. Unless there is sufficient water supply at appropriate time, fertilisers would not be used by crop plants and would thus yield much less even though fertilised. Much more work than what has been done so far will have to be done in future in connection with fertiliser usage. Sophistication has to be introduced in all these aspects of fertilisation i.e. choice of fertilisers, time of application as well as method of application.

20.2.29 Weeds do play havoc during some seasons. But the problem is not that serious as in heavy rainfall areas. Weeds can be controlled by adopting mechanical methods. When the crops are broadly spaced it would be possible to use the implements for removing weeds. Some perennial weeds, however, are serious in low rainfall areas. Nutgrass (*motha*) is a serious menace in red soil areas and *dub* grass in heavy soil areas. Some of the crops like groundnut and others, which are closely spaced, suffer considerably from weed growth. Appropriate chemical and mechanical methods would go a

long way in reducing the harmful effects of weeds. Since moisture and nutrients are consumed by weeds in competition with crop plants, the weeds have to be controlled at appropriate time by adopting suitable mechanical or chemical methods. Pests and diseases do appear seasonally and cause reduction in yields. Pests and disease resistant varieties and suitable pest and disease management practices also are required to be developed.

20.2.30 Farm power appears to be an important limiting factor in low rainfall areas. Many operations are required to be carried out in time to get maximum benefits. Opportunities for carrying out various operations occur in very narrow periods and come with suddenness. In some years, there may be only one opportunity for sowing a certain crop. If that is missed, it is as good as losing the whole year. To ensure carrying out the critical operations in time, the power requirement will have to be much more compared to the areas where climatic conditions are more favourable for carrying out such operations. The power availability in these areas at present is quite low and increasing the animal power may also be impracticable. It is, therefore, necessary to examine the need and scope for mechanisation. More work is required to be done with regard to improvement of implements, both animal drawn as well as tractor drawn. Work has to be done from engineering as well as from agronomic points of view.

20.2.31 These areas are very good for seed production. Because of prevailing dry weather for very long periods during the year, it is easy to store the produce. It is, therefore, advantageous if areas are marked out for seed production and also for storage of grains and seeds.

20.2.32 The land use survey if carried out would help in identifying areas which could be put under grasses and field crops and areas where irrigated farming could be developed. In general, it can be said that level lands which occur on the ridge could be put under field crops after taking appropriate soil and water conservation measures. The sloping lands would go better under grasses and trees, because these are highly erodable or already eroded. The valley portions could be developed as irrigated lands by making use of underground water resource. Wells could be dug or ponds could be constructed and water could be used for raising various kinds of irrigated crops including vegetables, fruits or seed of arable crops. It will be a highly paying proposition. Marketing facilities, however, will have to be developed to ensure economic returns where such cropping systems would be adopted under irrigation.

Certain Case Studies for Improving Production in Low Rainfall Areas

20.2.33 Recent studies have shown that, in the case of low rainfall areas, it is possible to avert total failure of crops provided that (a) the rainfall is not less than 40 per cent of the normal or not less than 300 mm; and (b) the growing season is not less than 60 days. Severe droughts resulting in total crop failures are less frequent than events such as slight delay in the onset of monsoon, extended inter-spells and a slightly earlier cessation of the monsoon. The inability to deal effectively with these mild aberrations results in highly fluctuating agricultural production in the drylands. Action plans to minimise fluctuations consist of the following steps :

- (i) monitoring of weather in a given season and early identification of the aberrant season ;
- (ii) implementation of alternative cropping strategies ;
- (iii) adoption of the strategy for growing fodder crops when it becomes clear that the season is no longer conducive for raising field crops ;
- (iv) emphasis on capitalising normal and above normal rainfall years.

20.2.34 The last point on capitalising normal and above normal rainfall years needs emphasis. Since rainfall and its distribution is a random phenomenon the above-normal rainfall years tend to be as frequent as those of drought. However, the preoccupation so far has been with the drought years and little thought has been given to capitalising the normal and above-normal rainfall years. It is felt that above-normal rainfall years, if utilised properly, will lead to surpluses which can be carried over and will make it possible to institute on a very large scale such works as establishment of grasslands, tree planting, etc.

20.2.35 Based on the above considerations, crop production plans have been prepared for the Anantapur and Ahmednagar districts as typical case studies under the All-India Coordinated Dryland Research Project (ICAR). These are described in the succeeding paragraphs.

Crop Production Plans—Anantapur District

20.2.36 The following are the factors limiting crop production in Anantapur District :—

- (i) Light shallow soils covering approximately 80 per cent of the cultivated area. Presence of compact sub-soils which restrict root penetration and proliferation. Low nutrient status particularly nitrogen and phosphorus and anticipated deficiency of potassium and zinc in the near

future.

(ii) Low rainfall of 350—560 mm during the crop season. Inter-spells of dry weather of two weeks' duration or more are common. The relatively more assured period is from August 27 to October 14, approximately 50 days.

(iii) Very little irrigated area mostly under tanks and wells which in turn are dependent upon local rainfall.

(iv) The major crop is groundnut (254 thousand hectares) which is shallow rooted and liable to moisture stress at several stages during the crop season. Lack of sufficient information on management of sorghum for the agro-ecological conditions in the district.

(v) Almost total absence of grasses and tree crops which are less sensitive to cyclic moisture stress.

(vi) Very low level management of the dryland crops.

20.2.37 Nearly 80 per cent of the Anantapur district is cropped in kharif. Rabi is confined only to black soils occupying 20 per cent of the district. Hence readjustment of kharif and rabi areas depending on the season is not possible and the focus should be on improving and stabilising production of kharif crops.

20.2.38 Although sowing rains occur in the last week of May/ first week of June, this is followed by a 4 to 6 weeks drought in the months of June and July and most reliable rains are from August 27 to October 14. Under these conditions, hardy crops like redgram, castor and mesta (*hibiscus sabdarifa*) could be sown with May rains while crops like bajra, setaria, cowpeas, *Dolichos lab-lab*, *Dolichos biflorus* and sunflower could be sown from third week of July to third week of August.

20.2.39 Groundnut is the most important crop in the district and it is also the most risky. Inter-cropping systems consisting of red-gram-groundnut or castor-groundnut are suggested to minimise the risk. On crusty soils and on soils with compact sub-soils groundnut could be avoided.

20.2.40 Sorghum : No breakthrough in sorghum production in the district is possible unless the kharif (June sown) sorghum could be converted into *maghi* (August sown).

20.2.41 Pearl millet : Pearl millet is a much more reliable crop than sorghum. The productivity of this crop could be further increased by deep ploughing within the seedlines. But for downy mildew and sometimes ergot problem, pearl millet is the safest crop for the district.

20.2.42 Horsegram and redgram : These are the two important pulse crops in the district. Yield of horsegram could be increased by fertilising with phosphates. New varieties of redgram with synch-

ronous flowering habit and of 150—180 days duration are likely to become popular in the district.

20.2.43 Rabi crops : In the black soils of Anantapur, the yield of rabi-sorghum could be improved by advancing the sowing date from the traditional mid-October to as early as possible in September. The risk associated with coriander crop could be minimised by inter-cropping it with safflower.

Crop Production Plans—Ahmednagar District

20.2.44 The factors limiting crop production in Ahmednagar district are :

(i) About 40 per cent of the total area of the district has shallow soils (less than 22.5 cm depth) which are highly eroded.

(ii) Rainfall is highly uncertain particularly from August 6 to September 2 during which time most of the 'kharif crops' would have entered the grand period of growth or the flowering phase.

(iii) Pearl millet is the principal crop grown on the shallow soils. Being shallow rooted, bajra suffers from moisture stress.

(iv) Topography is highly undulating leading to serious soil erosion and runoff.

(v) Medium and deep soils have an infiltration rate of 5—7 mm per hour which results in heavy runoff.

(vi) Due to absence of a dryland centre in the district, data will have to be projected from the nearby Sholapur centre.

20.2.45 The shallow soils (40 per cent of the cropped area), in which pearl millet is the most important crop, could be more advantageously utilised for short season grain legumes such as greengram or for intercropping systems such as pearl millet-redgram and pearl millet-castor. Hardy crops like *Dolichos lab-lab* and *Dolichos biflorus* could also be taken. The highly eroded shallow soils are best used for developing grasslands.

20.2.46 On the whole, the kharif cropping in the shallow soils will continue to be highly risky. Medium deep soils occupy about 40 per cent of the cultivated area. Based on the experience at Sholapur, it seems profitable that these soils be cropped either in kharif or in rabi depending on the season. The practices developed for improving sorghum and safflower yields at Sholapur could be applicable to Ahmednagar district. The only specific point is that the sowing of rabi crops could be advanced much further, i.e., they could be

sown from mid-August to end of August in Ahmednagar district.

20.2.47 It will be worthwhile that the studies on the models of Anantapur and Ahmednagar districts, which have been described above, are also made for all the 72 drought-prone districts of the country. When the studies have been completed, the important results could be implemented as farmers' programmes for drought proofing of the areas concerned.

Basic Practices for Agricultural Planning in Drought Prone Areas

20.2.48 One need not wait for the studies which have been recommended above. There are certain practices which the individual dryland farmer can adopt to ensure better moisture regime in a cropping season. One of the important rainfall characteristics to be considered in this context is that there are a few intense showers, the intensity of which exceeds the rate of infiltration, contributing to runoff, to about 10 to 20 per cent of the annual rainfall. While on the one hand these do not ensure complete *in situ* intake of rainfall on the other hand, they provide immense scope for water harvesting and subsequent use of stored runoff. Hence the measures that could be taken up should be those intended (a) to maximise available moisture supply in the profile and (b) to harvest, store and recycle runoff water for crop production.

20.2.49 When water storage is a part of the scheme, the first thing that comes to the mind is the use of surface reservoirs. Ideal locations especially in cultivated fields are difficult and part dug outs have to be used. Such tanks range in size from farm ponds with catchments between 1 and 10 hectares to small tanks with catchments of less than 1 ha and are being studied at the different soil conservation research centres of the ICAR. In a system worked out at the Dryland Research Farm at Hyderabad, a dug out tank with a catchment of 0.5 ha is made at the end of a graded bund; the earth spoil being used for the graded bund itself. In the determination of the size of such tanks, one criterion may be the volume of water that would be required to give a minimal irrigation of 1 cm to 1.5 cm for the catchment. It is also important to bear in mind the earth work to storage ratio in the selection of site and design of the tank. Certain site specific problems as seepage in the red soil areas of South India, may be encountered, involving use of sealants. Two types of sealant materials could be used (a) the best sealant with a high initial cost and low maintenance cost and (b) a less effective sealant of local materials with low recurring cost. Based on the work done at Hyderabad, asphalt spray of 0.25 cm thickness a four inch plaster of a mixture of sieved surface soil, cowdung and straw (10 : 1 : 1) appear

promising for the red soils of Telengana. In areas where evaporation losses are high, use of floats could be adopted.

20.2.50 Mulching reduces moisture losses. Best results are obtained when the mulch covers the entire soil surface. Mulches of different kinds are used, viz., organic mulches, plastic mulches, gravel and soil mulches and even chemical or petroleum products. An ideal mulch should decrease evaporation while permitting infiltration, should not interfere or be destroyed by normal farming and should be economical. Thus the most practical type of mulching in the dryland tracts of India would be soil mulch or dust mulch itself, created by stirring the surface of the soil to keep it loose and receptive to rains during the cropping season. Mulches have been particularly effective in minimising moisture losses from the seed zone. Reduction in evaporation from soil surface has been reported through the use of shelter belts of trees, in areas prone to high velocity winds. Weed control reduces loss of stored soil moisture.

20.2.51 Earlier, the emphasis was on erosion control, but the present trend is to combine soil conservation and water management. Thus in many areas, the main engineering structure is a graded bund or a contour bund with waste weir. The specifications of bunds vary from region to region, the cross section ranging from 0.75 to 1.5 m^2, depending on the nature of the soils. Another practice of great potential is the practice of vertical mulching (organic trenching), which consists of keeping trenches filled above the soil surface with crop residue (oriented vertically), as specific intervals. This practice is recommended in situations where other practices fail as in light soils with high structural instability. Greater intake rates are achieved also by leaving the soil surface cloddy. Where sub soil hard-pans occur, deep ploughing and chiselling will enhance the water absorption into the soil profile.

20.2.52 When crops are considered for drought-prone areas, we have always been in favour of providing amply for fodder crops too. This step is very necessary in order to save the livestock which is maintained in such areas. It so happens that many of the dry areas are the breeding grounds for farm animals. In times of drought, there is mass scale migration of cattle and sheep etc. to more congenial situations. However, much of the stock perishes even during migration because of lack of fodder in the way. Creation of fodder banks along the route of migration would take care of feeding problems during drought periods. About 100 ha blocks in marginal forest, grasslands along the route require to be earmarked for production. In the blocks, introduction of legumes like *Stglosanthes humilis* and *Siratro* will enhance the quality of hay. Top feed species like *Leucaena leucocephala* can also be introduced which gives high dry matter yield

when cut at 30 cm height at interval of 40 days. The fodder banks may contain at any time a storage equivalent to three years production from a good season. If at the end of three years, a good rainfall year prevails, the reserves of fodder bank may be sold and a fresh storage for three years shall have to be made. This way the hay can be renewed periodically. Fire prevention is essential.

20.2.53 In view of the available technology, it is recommended that any strategy for crop planning in drought-prone areas in the country should include the above mentioned basic practices as essential constituents of the package programme for implementation under a rational system of land utilisation.

Farming in Medium Rainfall Areas

20.2.54 Vast areas in the country come under medium rainfall, where its annual amount is neither too high nor too low. On one side of the tract there are heavy rainfall areas and on the other low rainfall areas. The annual rainfall in the medium rainfall areas varies between about 75 and 150 cm. It could vary every 15 km or so. However, broadly speaking, these areas could be divided into high medium rainfall areas and low medium rainfall areas. While the low medium rainfall areas are fairly well developed the high medium rainfall areas lag behind. In the latter areas paddy dominates and even in low medium rainfall areas paddy has crept in. Wherever the cropping has been adjusted according to the rainfall distribution, there high yield levels are observed. But, wherever there is emphasis on high water requiring crops like paddy, the yields are quite low. The main thing, therefore, that is required to be done in the transitional belts is to work out appropriate cropping patterns taking into account the soil conditions and elevation features. In the belt adjoining the heavy rainfall areas, naturally, it would be possible to allocate the low lying areas to paddy crop. Even the high lying areas are put under paddy at present. If paddy can be restricted to low lying areas and that too after making arrangements to divert surplus water from the surrounding high lying areas, paddy can be grown quite successfully. After demarcating such areas for paddy crop, the remaining areas could be devoted to crops that require less water than paddy but more water than millets. These crops are mainly maize, cotton, soyabean and the like. Maize comes up well with such pattern of rainfall and similarly cotton and soyabean could be grown successfully in these areas according to soil type. At present, these areas are poverty striken—not because of poor resources but because of poor resource management. Soil and water resources are fairly good in these zones. Soil is fairly fertile although deficiencies

of some nutrients may be observed in some places. Because of good water resources, response to application of fertilizers is remarkable. It is possible to supplement water resources by having a number of tanks and wells. Though it would not be possible to have irrigation for all the twelve months, it could be provided at least for eight months. Growing of fruit crops and vegetable crops could be quite successful. Animal production, especially dairy animals, could be quite successful. Sheep farming may not be advisable. Piggery and poultry could be introduced with advantage.

20.2.55 East Uttar Pradesh, Bihar, Orissa, West Bengal, East Madhya Pradesh and adjoining parts of Maharashtra (Vidarbha) receive a rainfall of about 30 cm or more in July and August and between 20—30 cm in June and September. If all the four South West monsoon months had got a rainfall of 30 cm or more per month, it could be ideal for paddy. Despite this not being so, farmers are tempted to go in for paddy because of July-August rainfall, but this proves insufficient and hence the crop suffers in later months. The remedy to this situation has already been suggested in the earlier paragraph. In contrast to this, there is another extreme where fields are left fallow totally in kharif season because of the insufficiency of rainfall during June and September months for paddy growing and excess of July and August rainfall for many other crops. The farmers also try to escape the menace of weeds in this manner which grow profusely in kharif season and overwhelm other crops. Central Madhya Pradesh is a typical example of this kind, where vast areas are left fallow during the kharif season. The cultivated area involved is more than 2 Mha. A part of the kharif fallows is under *haveli* cultivation. The *haveli* cultivation really means that fields are bunded and water is allowed to stay during the rainy season. These are generally flat lands with very small grade. The water does not evaporate entirely but actually by the end of September or beginning of October it is allowed to drain out and then a beginning is made by sowing rabi crops like wheat, pulses and oilseeds. Wheat is the main crop and is sown towards November beginning. It should be clear that a good lot of water is wasted away in this manner without being directly utilised for growing crop during kharif season.

20.2.56 Experiments on the utilisation of the fallow lands of Madhya Pradesh indicate that the flat lands are ideally suited for paddy cultivation. Often, no other crop gives worthwhile return in such a situation due to too much soil saturation and spoilage by rains. Early paddy followed by pulse crop has been tried with fair amount of success. Otherwise, one kharif crop can be taken. The farmer is reluctant to adopt such a practice since rabi crop is less risky and kharif crop (even paddy) may suffer for want of water during drought

spells. Irrigation water can, however, give stability and insurance to both kharif and rabi crops. For such lands, the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, has undertaken an experiment for taking soyabean on raised beds alternating with paddy beds 6 metres in breadth. There are indications that both the crops do well generally. For lands, which have a slope to the extent of 1-3, the water can be drained off and collected in a farm pond at the end of the field. In their experiments, they lead the water from the micro catchment areas in such a manner that it automatically passes through paddy crop before reaching the farm pond. On the slope is taken the soyabean crop. The water collected in the farm pond can also be utilised for one or two irrigations in rabi season. This drained water collected in the farm pond can also be used for kharif crop, particularly paddy, if there is prolonged drought. All these ways of water management are worth adopting so that kharif crops could be introduced successfully in vast areas which are left fallow at present.

20.2.57 There is large scope for developing better mixed farming as well as relay cropping practices in areas of high medium rainfall. It is especially so in areas where the rainy season is spread out starting before the on-set of monsoon and ending in the post-monsoon period, as is obtainable in some eastern and southern parts. Soil and water conservation measures, however, would have to be taken in an adequate manner in all such cases. If not, soil is likely to be washed away especially from slopy areas. If the lands are very sloping as found in the Himalayan ranges, it is better to go in for fruit farming combined with dairy farming. It is possible to set aside certain areas which are highly erodable for development of forests. Medium rainfall areas are the best areas for rainfed farming. Potentialities are tremendous both for arable cropping as well as for animal farming and raising of forest trees. Problems of developing infrastructure would naturally arise. Processing, storage and marketing facilities will have to be developed to exploit these areas to maximum potentialities. At present, these are least exploited. On the contrary, there has been too much of pressure of population without developing the resources. Pressure of population cannot be said to be very high but the existing population is not having full opportunities to utilise the resources available in these regions. There used to be problem of public health in earlier years, but now it is not that serious. By developing suitable mixed farming systems for these areas, higher population can be sustained.

20.2.58 The belt adjoining low rainfall areas has vast potentialities. Rainfall is sufficient for raising many of the arable crops. Kharif jowar dominates this zone. Even maize can be taken with advantage. Cotton is a good crop for this zone. Soyabean and a

number of other pulses are being taken and yields are fairly high. There is possibility of developing water resources through tanks and wells. Growing of vegetables and fruit crops is advantageous. Dairy farming also can be introduced without much difficulty. Possibilities of developing suitable rotations including leguminous fodder crops would go a long way in maintaining soil fertility in these areas. At present, groundnut forms an important crop and many pulses also are taken which are helpful in maintaining soil fertility. Sunflower can be introduced with advantage. Even in this area, in some parts, drilled paddy is taken, but the yield levels are quite low. It is better to do away with paddy crop in this zone and concentrate on cereals like kharif, jowar, maize and ragi. There are a number of pulses and oilseeds which could be taken in rotation with these cereals. As stated earlier, possibilities of introducing forage legumes also could be considered. Some area could be set apart for man made forests especially those areas which are sloping and are, as a result, erodable. The soil fertility is observed to be on high side. Response to application of fertilisers is good because of appropriate water support. Alkalinity and salinity are not commonly observed to be the problems. Natural vegetation in these areas has been grass with some sprinkling of trees. Therefore soils are fairly fertile having good amount of organic matter. These zones are fairly well developed even now. Scope exists for introducing new crops and developing better rotations and also mixed cropping practices.

20.2.59 In all these areas of medium (high or low) rainfall as a whole, power requirements would be high. Problem of weed control is fairly acute. In some areas, it is difficult to remove weeds using human labour because of continuous rainfall for a number of days. It is, therefore, advantageous if suitable chemical methods of weed control are developed and popularised. Pest and disease problems are serious because of high humidity. Therefore, introduction of pest and disease resistant varieties is an urgent need, without which crop yields are likely to suffer. Deep tillage is quite necessary in these areas. The studies carried out so far indicate that it is advantageous to till the soils deep for better drainage and weed control. For all these reasons the power requirement is likely to be high. It is, therefore, necessary to introduce either more bullock power or machines.

20.2.60 It can be said that the potentialities in medium rainfall areas are tremendous. There is considerable scope for improving the cropping systems. The main objective should be to fit the crops into climatic rhythm prevailing in these areas. The risk in farming could be reduced considerably by growing crops like maize, jowar, soyabean etc., instead of attempting to grow crops that would require much larger quantities of water. There is considerable scope for improving

the cropping systems with this object in view. More research work is required to be done with regard to cropping systems as a whole, keeping in mind at the same time the possibilities of introducing forage crops either in rotation or as mixed crops.

3 IRRIGATED FARMING

20.3.1 The climatic conditions in most parts of the country are favourable for raising crops practically throughout the year provided water is available for irrigation and temperature is not a limiting factor. It is for this reason that multiple cropping even to the extent of 3 to 4 crops is possible in India if water facilities are available. The water resources of the country have been indicated in Chapter 15 on Irrigation. The need for developing water resources for increasing agricultural production has also been discussed in detail in that chapter. While irrigation support will obviate the harmful effects of occasional drought in good rainfall areas, it would make possible the growing of commercial crops in low rainfall areas. Irrigation, if available during off season, could help in extending the cropping period as a whole and thus make it possible to adopt intensive measures for increasing production, which in turn would help in increasing employment opportunities. Where water resources are available in plenty, it would be advantageous to raise crops like paddy, which would require large quantities of water and which would yield large quantities of grain. Where land is plenty and water resources are limited, it is better to go in for those crops which require less water so that it would be possible to cover as large an area as possible under irrigation.

20.3.2 Depending upon the source of water supply, it is possible to get irrigation water for almost the whole year or for eight months in a year *i.e.,* two seasons or just for one season in either kharif or rabi or occasional just to support the common crops grown in an area. Where irrigation is available perennially, it is possible to grow crops like sugarcane, fruit crops and some plantation crops which are perennial in nature and require irrigation throughout the year. In areas where water is available for eight months either long season crops like cotton can be grown with advantage or two crops each of 3½ to 4 months duration can be raised. Major and medium irrigation projects supply water either for eight months or throughout the year. In recent years, however, with a view to making water available to as large an area as possible, water supply is restricted to one season only. A part of the area is supplied water during kharif

season and the another during rabi season. Minor irrigation works and other miscellaneous types of irrigation works like diversion channels etc., can supply water mostly for one season. Tubewell irrigation system can supply water perennially if the underground source is good. Similarly, water supply from dug wells is usually available for eight months or more. Depending upon the source of water supply for irrigation and the period for which water becomes available, farming systems have been developed and adopted. The main aim in irrigated farming has to be to increase the water use efficiency. The system that yields maximum produce per unit of water would be the best. It is with this object in view that farming systems should be improved.

20.3.3 There are a number of fundamental issues that have to be considered in developing farming systems in irrigated areas. One of these questions is whether summer irrigation should be encouraged. If water is available throughout the year it becomes possible to raise crops in all seasons including the summer season. In such situations, it is a boon to have enough water for irrigation during summer and it should be made use of for raising those crops which would give maximum returns. In areas where water has to be stored for a long period to make possible raising irrigated crops during summer, it has to be considered whether it is advantageous to do so. Summer season is usually free from pests and diseases. High value crops can be raised with great advantage during that season. The tendency in many parts of the country is to encourage growing of paddy during summer months because of the possibilities of getting very high yields. With the introduction of high yielding paddy varieties, this tendency is increasing. The question whether it is a desirable practice is still unsettled. To raise a crop during summer, water has to be stored right through the winter season; evaporation losses naturally become very high during the prolonged period of storage. In spite of this disadvantage, growing of paddy during summer has proved profitable. Because of clear season, manipulation for getting very high yields is possible. It is, therefore, necessary to leave it to individual farmer to decide whether it is desirable to raise paddy during summer taking into consideration the advantages and disadvantages of such a cropping system.

20.3.4 Another question that is usually debated is whether there should be intensive irrigation or extensive irrigation, whether the same area should get water for 8 to 12 months or available water should be distributed over larger area by making it available only during one season. For instance, if water is available for eight months, should half the area get water for one season and another half area during another season or should half of the area get water during

both the seasons. In the former case, the beneficiaries will be a larger number of farmers at any given time.

20.3.5 There are advantages in adopting intensive system. One of the main advantages is that the total investment required for land development would be less, but the disadvantage is that less number of farmers will get the benefit of irrigation. It has been the practice in recent years to adopt extensive irrigation rather than intensive irrigation. The extensive irrigation system can be improved to go a long way if water that becomes available is made use of in conjunction with rain water and also with underground water that may become available in some areas. In areas where irrigation water becomes available during rabi season, it may be possible to raise crops during kharif season by making use of rain water supplemented by one or two irrigations. This means that farmers can raise two crops—one under full irrigation and another under supplemental irrigation. If underground water is available, it may be possible to raise crops practically throughout the year using irrigation water during the season it becomes available and using the underground water during the period when there is neither sufficient rainfall nor flow irrigation. Studies that have been carried out all over the country are such that they are not very helpful in developing cropping systems based on the idea of conjunctive use of rainfall, flow irrigation and ground water. More studies are required to be carried out with this object in view so that it would be possible to develop cropping systems with better water use efficiency.

20.3.6 Cropping systems in irrigated areas can be developed with a view to making the best use of all the resources that are available under a particular situation. The possibilities of adopting advantageous rotations and better cropping patterns are tremendous under irrigated farming. The need as well as the scope are considerable. Similarly, mixed cropping, relay cropping and inter cropping possibilities are also tremendous. Once water is under control, it is possible to manoeuvre the cropping systems to the best advantage of farmers. At present, the cropping systems are developed taking into account the availability of irrigation water only. As stated earlier, the conjunctive use of irrigation water with rain water and ground water is not thought of. In major and medium irrigation project area, water is made available to a portion of the area during one season and to another portion during the other season. At present, taking crops under rainfed conditions during the season when water is not available is not very common. If rainfed cropping could be encouraged in such a manner that maximum use of rainfall could be made for raising crops without dependence upon irrigation, and water is provided only in other situations, the intensity of cropping

will increase considerably. In this manner, it could be possible to increase the production to a very great extent in all the project areas.

20.3.7 To encourage farmers to take to rainfed farming in the season where irrigation water is not available, it may be advisable to provide one or two irrigations to start the crop well ahead of season. Likewise it may be advisable to encourage farmers to have their own wells to supplement irrigation water supply. By adopting various measures of this kind the season of growing can be extended considerably. This would provide considerable scope for adopting relay cropping and intercropping. The practice of growing maize and *tur* (arhar) as mixed crops in canal irrigated tract, where water becomes available for eight months, has been proved to be better than taking two crops of maize. Growing of sannhemp in between maize lines for green manuring purpose has been proved to be very efficient method of maintaining soil fertility. After green manuring it is possible to take a second crop during rabi season. Studies carried out so far have not explored the possibilities of introducing leguminous forage crops in rotation with various field crops. Possibilities of introducing lucerne as rotation crop are considered good. This practice would help in maintaining soil fertility at a high level.

20.3.8 When intensive cropping is adopted, maintenance of soil fertility assumes increased importance. More inputs have to be provided to facilitate taking more number of crops in a year. At the same time, maintenance of soil fertility would not be difficult provided cropping systems are developed and adopted in such a way as to include leguminous crops in rotation. Continuous cropping with only one type of crop may lead to serious consequences, but the problem can be minimised by growing crops having different rooting habits. Attempts should be made to take green manure crop as a catch crop wherever possible. Similarly, specific attempts should be made to introduce leguminous crops preferably forage legumes in rotation. Maintenance of organic matter content at a high level is not very difficult, provided care is taken as stated earlier to take green manure crops and leguminous fodder crops. From chemical point of view also it is not very difficult to maintain the soil fertility because of the scope for using inorganic fertilisers. Risk involved in using large quantities of fertilisers is not much. It is, therefore, necessary to apply fertilisers as and when required according to the needs of soil and crop.

20.3.9 Physical condition also can be maintained well, provided care is taken to carry out tillage operations taking into account the soil conditions. Deep tillage is very necessary. Only care that is required to be taken is to see that the tillage is done when the mois-

ture condition is optimum. If it is carried out when the soil is too moist, the physical condition is likely to be affected adversely. Another important care that is required to be taken with regard to soil condition is the drainage. Surface drains as well as underground drains are required to be provided according to the needs. The former help in leading the storm water out without causing any damage to irrigation layouts and at the same time keeping the crops unaffected from temporary waterlogging. Underground drainage system is required only in low lying areas, where the danger of water accumulation exists. Sometimes, it is suggested that, along with the water distribution system, drainage system should also be developed. This should be done with care. Underground drainage should be provided where it is necessary rather than providing surface drainage everywhere. The problem of water logging could be reduced to a considerable extent if the natural drains are maintained in condition. This does not happen everywhere. Care should, therefore, be taken to see that underground natural drainage is not impeded on any account. If care is taken to see that such impediment does not take place, then the problem of drainage could be reduced to minimum. It is especially so in level alluvial areas, as in the North. Underground drainage system may have to be provided as a rule at least in some parts in these tracts.

20.3.10 Power availability has to be improved if intensive farming systems are required to be adopted. Land has to be prepared quickly and in many cases harvesting has to be done in short period to enable the adoption of multiple cropping programmes. Power availability is better in irrigated areas as compared to dry areas. This will have to be substantially increased if multiple cropping programme is to be adopted on intensive scale. The dearth of power is being felt in irrigated areas already. A lot of damage to standing crops is reported to have occurred for want of labour to harvest the crop in time. In such circumstances, mechanical power has to be introduced even for harvesting purpose.

20.3.11 The conditions prevailing in irrigated areas are favourable for development of pests and diseases. Continuous cropping and high humidity and lush growth of vegetation are the conditions that are very congenial for development of pests and diseases. Similarly, weeds assume importance. Controlling weeds with human labour may become difficult. It is, therefore, advantageous to develop chemical methods of weed control. Work in this direction will have to be intensified. Perennial as well as annual weeds assume serious proportions. Perennial weeds in water cause considerable damage to water courses. Control of such perennial weeds could be possible only through chemical methods. The work done on this aspect is

not sufficient. More intensive work is required to be done to develop proper practices in this regard. Pests and disease control methods are becoming available and they are being popularised also through extension organisations. The only thing that is required to be done is to develop pests and disease management practices. The problem has to be seen in totality and not from individual pests and disease point of view.

Riverbed Farming

20.3.12 Areas lying adjacent to or surrounded by a river have their own problems. The lands under the influence of such rivers which have water supply for the major part of the year are utilized for crop production. Such lands along the course of the Himalayan rivers which traverse Uttar Pradesh, Bihar and West Bengal have attracted special attention. These are variously called as *khadir* (West and Central Uttar Pradesh), *diara* (East Uttar Pradesh and Bihar), *char* (West Bengal). Their extent in Uttar Pradesh and Bihar alone has been estimated at about 2.4 Mha[1]. The *diara* area could be classified into (a) low bank or *khadir* region, (b) slightly higher middle region also called *tarai* and (c) trans-*khadir* upper relatively flood-free region. This kind of three-tier topographical feature is typical of any river, but the total width of all the three taken together may vary considerably depending upon the terrain along the river course. In extreme cases, the width could be as much as 25 km. or so.

20.3.13 The Government of India constituted a Technical Group in September, 1971 to consider the problems of *diara* lands which submitted its report in 1972.[1] It covered all aspects like soil fertility, soil management, development of minor irrigation, flood control, land development and reclamation, crop production, plant protection, research, input supplies, credit, electrification, communication, marketing, extension and education, fisheries, animal husbandry and micro-level planning.

20.3.14 We should like to lay special emphasis on the direct riverbed cultivation, which limits itself to a few hundred metres' width along the river course. Besides utilization of water for crop raising through direct rainfall or irrigation, riverbeds serve to provide soil moisture to plants in an easy way because of very high water-table. Rivers recede substantially by the month of October. Cultivation in the receded beds and even in the islets is a common sight between November and June. Cucurbits like various kinds of gourds, cucum-

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1 1972. Report of the Technical Group on Diara Areas in Uttar Pradesh and Bihar. New Delhi, Department of Agriculture, Ministry of Agriculture & Irrigation, Government of India.

bers (*kakdi, khira*) and melons (*kharbuja, tarbuz*) are a speciality of riverbed cultivation. Amongst the field crops are seen even wheat, mustard and peas, but maize for cobs in April-June period is more common. Vegetable crops like potato and brinjal also figure in places. Brinjal produced in sandbeds (*reti-ka-baigan*) is understood to be more delicious than when grown in other situations. People, who have chosen to do this kind of cultivation, stick to it and do not prefer other kinds of cultivation. Special methods of cultivation have also come in vogue by usage. With the advance of season, when the water-table recedes, the cucurbits are planted in pits so as to allow them to maintain contact with the water-table during summer months. The vines are either trailed in furrows or over surface duly protected by thatched *tatties*, which act as windbreaks. The way these farmers grow the crop, is their own innovation. There is no guidance to them from scientists and extension workers worth the name. This state cannot be permitted to continue if all possible kinds of land bits are to be put under intensive methods in order to maximise production. Riverbed farming should be developed as a special form of cultivation. The work will have to be organised from a scratch; the crops to be preferred under a given set of conditions, the varieties and the methods of cultivation and care, manurial and plant protection problems—all need to be tackled and then a proper advisory service on the extension side must be kept ready for helping the growers.

Sewage Farming

20.3.15 Utilization of sewage water is another promising avenue to increase the scope of irrigated farming. The concept of use of drain water is nothing new in the country. In larger villages, towns and cities not served by modern sewerage, people usually make a provision to lead the discharge from their house-drains to their backyards where a small kitchen garden is raised or a few clumps of banana plants are grown. Preference to high water consuming plants like banana is given so that slush could be avoided. In cities like Agra and Gwalior, where wide open drainage canals pass through the city, it is a common site to see the vegetable growers having carved out their vegetable plots along both the banks of the central channel. Flower plants and fruit trees like papaya are also grown in between. In Poona, the effluent of city drainage is mixed in certain determined proportions with the waters of canal distributary. The mixture of water is utilised for irrigating agricultural lands in the areas served by the distributary. Vegetables, grape and sugarcane cultivation in Hadapsar, a suburb of Poona, is fully sustained by this kind of

irrigation. In Delhi, the diluted effluent is widely utilized for irrigation of lawns and horticultural establishments of the Central Public Works Department (CPWD). This kind of utilisation has to be popularised more and more in all the cities presently served by a well-developed sewerage system. In addition, underground sewerage has to be extended with the same purpose in view to all other towns and cities so far uncovered by this system. The State Governments should provide necessary financial help to municipalities in order to enable them to do the job. A system of levying irrigation charges could be developed, which would repay the investment to a certain extent and the balance could be considered as a part of Governments' developmental responsibilities.

4 CROPPING SYSTEMS

20.4.1 Farming systems, which have been considered in the previous sections, determine the broad pattern of agriculture practised in a particular region or country depending upon natural, demographic and economic factors. Cropping systems constitute an essential practical step, through which the objective of a particular farming system is fulfilled. For example, arable farming is one type of system, in which various kinds of food crops or commercial crops are cultivated involving different field practices of tillage, manuring and irrigation etc. Issues like the crops to be grown, the manner of growing them and the intensity of manuring and irrigation are all determined by a particular type of cropping system followed within a particular type of system of arable farming. Similarly, ley farming is a system of engaging the fields in pastures; but what grasses to be grown, on what soils, in what manner is all represented only through a specific cropping system relevant to a particular situation. Farming system in a particular region is more permanent than the cropping systems obtaining within it. For example, over hills in high rainfall areas the system of raising plantation crops is more or less an established fact; but what crops are grown could vary from time to time depending upon changing patterns of likes and dislikes, economic considerations and pressures of demand of internal or foreign markets.

Systems of Multiple Cropping

20.4.2 There was a time when the country's economy could allow a system of cropping, in which everyone tried to produce whatever he needed for his own requirements. The pressure on land and resour-

ces was not heavy. A farmer managed to take many crops of his needs without difficulty in a time sequence and planned manner on irrigated lands. In rainfed conditions, he chose to gamble by throwing seeds of as many crops as possible all at one time in the same field in order to ensure that at least one or two of the crops would give him some return. It is this philosophy which laid the foundation of mixed cropping. Farmers are used to broadcast seed mixtures of jowar and pulses, bajra and pulses, jowar/bajra and *tur* (*arhar*), wheat/barley and gram/pea/mustard and so on. This practice has gained sophistication in course of time and many progressive farmers have started taking mixed crops in lines, a system also called inter-cropping. The crops could alternate with each other in the same field, each occupying a specific width in a specific sequence. This came to be known as strip cropping and is considered advantageous to check soil erosion. Companion cropping is another term, which is often used to denote the growing of more than one crop in the same field in a common period of time. For example, sugarcane can occupy the main field and its borders and bunds be put under crops like wheat and sugarbeet. The system of mixed or companion cropping is commonly used in growing vegetables. Leafy and root vegetables are often grown in the same field along with some other main vegetable crops. Then, there developed a system of relay cropping in which a rotational crop is planted at the maturity stage of the previous crop. Vast areas in East Madhya Pradesh and adjoining parts of Bihar and Orissa are sown with *lathyrus* (*khesari dal*) in paddy fields in this manner. This practice of relay cropping has also existed in vegetable gardening. More the pressure on land and resources, more is the need for all these kinds of multiple cropping.

20.4.3 Multiple cropping is one way of economising resources and yet getting increasing returns. Another way to get increasing returns from a unit piece of land is through multistorey cropping in orchard and plantation crops, i.e., utilise the underspace for some vegetable or pulse crops or even take some vine crops like pepper or betel. Ratooning economises resources in yet another way, viz., by doing away the investment in preparatory tillage and seed material and giving the new crop the benefit of an established root system. Ratooning is an established practice in sugarcane. A thinking is now developing to resort to this practice in high value crops like hybrid sorghums or even in hybrid cottons. The pressure on land utilisation is becoming so intense that, in the case of transplanted crops, scientists are thinking to utilise the main fields for raising some short duration catch crops, specially pulse legumes or leafy vegetables in the interval when seedlings are grown in nurseries. The practice of transplanting is most commonly adopted in paddy and some vegetables; it is being considered for

being extended to crops like bajra and ragi on a scale not so far undertaken.

20.4.4 The agricultural colleges, research institutions, experimental farms and lately the agricultural universities have all been developing better farming practices. Scientific literature is replete with experimentally proven results of crop combinations suited to various kinds of multiple cropping. In fact, if there is one field in which a lot of effort has gone in and which is even now popularly preferred for experimentation by scientists and post-graduate students alike, it is this. However, there has always existed a wide gap between the knowledge available in scientific spheres and what is actually pursued in practice by farmers. In order to fill in this lacuna, the ICAR undertook in 1957 through an all India scheme the preparation of an inventory of the methods and practices of farming actually followed by the cultivators for the major crops in various agro-climatic regions covering different States. The States studied were Jammu and Kashmir, Himachal Pradesh, Punjab, Rajasthan, Uttar Pradesh, Bihar, Andhra Pradesh, Orissa, Madhya Pradesh. Tamil Nadu, Kerala Tripura and the Union Territory of Delhi. The survey included information on lands use, cropping patterns and salient features of cultivation of important crops like land preparation, manuring, irrigation, plant protection measures and harvesting. Important rotations followed were also noted and a special mention was made about the farming practices as followed by some progressive cultivators. A report presenting all the information collected has been printed recently and it includes a recommendation that "in each State or region in the State, the progressive cultivators' practices should be given wide publicity as a package for the purposes of increasing yields. Steps would be needed to ensure their inputs for fertilisers and for the plant protection measures, both of which require direct expenditure on the part of the cultivators."[1]

20.4.5 Recent times have shown a shift from crop production as a means of subsistence to commercialised production. This has necessitated the use of high yielding and high fertiliser responsive varieties, many of which are not season-bound and hence are capable of being grown more than once in a year. Such a change from the old to the new order offers an opportunity to take stock of the existing cropping systems in order to determine which ones will prove beneficial in future. Accordingly, the Indian Council of Agricultural Research arranged a Symposium on Cropping Patterns in 1968. Working groups consisting of agronomists, soil scientists, meteorologists, statisticians, agricultural engineers, plant protection specialists, economists and plant scientists were formed for every State for

1 1971. Investigations into Methods and Practices of Farming in Various States, New Delhi. Indian Council of Agricultural Research.

examining the existing and future status. About 80 papers from all over the country were reviewed under seven broad groups, viz., agro-climatic and soil zones; cropping pattern in different States; problems of soil fertility and fertiliser use in relation to cropping patterns; water use and soil management problems of cropping patterns; engineering power and energy aspects of cropping patterns; plant protection problems of cropping patterns; and economic, marketing and storage problems of cropping patterns. The States considered were Jammu and Kashmir, Rajasthan, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Gujarat, Madhya Pradesh, Maharashtra, Bihar, West Bengal, Orissa and Assam. Besides various aspects, specific agronomic recommendations were laid down for different parts of the country indicating the existing and proposed crop rotations as well as cropping intensities.[1]

20.4.6 The feeling in favour of multiple cropping system has been so intense that closely on the heels of earlier development came a symposium on this subject in 1972; it was jointly sponsored by the Indian Society of Agronomy, Haryana Agricultural University and the ICAR.[2] The records of the Symposium contain numerous scientific papers relevant to different parts of the country. Individual contributions vary in content, style and emphasis. Some of these are very exhaustive and do justice to all kinds of regions, soils, irrigated and unirrigated areas. An example of an attempt on right lines is given in Appendix 20.1.

20.4.7 Companion cropping in sugarcane with wheat and sugar-beet, which is the thinking of the Indian Institute of Sugarcane Research, Lucknow, has already been once, referred to earlier. The Symposium on Multiple Cropping indicated some other alternatives like lady's finger (Sugarcane Research Station, Anakapalli, Andhra Pradesh) and even maize (Sugarcane Research Station, Padegam, Maharashtra). Cucurbits are already taken with sugarcane towards its planting time in various parts of the country.

20.4.8 The Indian Horticultural Research Institute, Hessarghatta (Bangalore) has indicated various intercroppings with banana in the following manner :—

I. Assam, Bihar, West Bengal, Uttar Pradesh and Gujarat :

(i) moong (p. *baisakhi*)—toria
(ii) cowpea (p. *dofasli*)—radish
(iii) cucumber or pumpkin—moong (p. *baisakhi*)
(iv) moong—turmeric/ginger/coriander

1 1972. Symposium on Cropping Patterns in India. New Delhi, Indian Council of Agricultural Research.
2 1972. Symposium on Multiple Cropping. New Delhi, Indian Society of Agronomy.

(v) groundnut—bottle gourd
(vi) okra (p. sawani)—cowpea (p. dofasli)
(vii) maize (composite)—cowpea (p. dofasli)

II. Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu and Kerala :

(i) ragi (purna)—field beans (lal-lal)
(ii) hybrid jowar/hybrid bajra—beans (contends)
(iii) groundnut—beans (contender)
(iv) sesame—peas (green pods)
(v) cowpea (p. dofasli)—radish
(vi) cowpea (p. dofasli)—cucurbits (pumpkin)
(vii) field beans—squashes
(viii) radish (Japanese white)—cowpea—radish

20.4.9 The Central Tuber Crops Research Institute, Trivandrum has suggested the following kinds of multiple cropping involving tuber crops :—

(i) tapioca, yams amorphophallus as intercrops in coconut and arecanut
(ii) tapioca and yams as intercrops in rubber
(iii) coffee, tea and cashew (during the first two to four years)
(iv) tapioca in rotation with banana once in two years
(v) legumes like cowpea, groundnut, black gram, green gram, sannhemp, soyabean and vegetables like *bhindi,* coleus as intercrops in tapioca and amorphophallus in low lying areas
(vi) rice—rice—sweet potato
(vii) rice—rice—colocasia/coleus/pulses.

20.4.10 It should be clear from the above review that there is no dearth of research material on multiple cropping and the opportunities for effecting changes in the cropping systems are also tremendous. The two symposia referred to above have indeed increased the awareness on the subject among the scientists, but a systematisation of the whole thinking has not yet taken place to an extent at which various alternatives could be placed before the farmers. One more attempt is needed to sift the results and rearrange them for practical utilisation taking into consideration the soil types, their local variations and defining possibilities of adoption of various crop rotations under rainfed conditions of different durations and amounts, under perennial irrigation, 6-9 months irrigation or one—season irrigation or occasional irrigation. It will be good if the next attempt is made at the taluk level and a concrete programme of educating the farmers in the new techniques is chalked out and effected actually through active extension

efforts. There should also be some machinery to evaluate the effect in each taluk and make mid-course alterations according to exigencies.

5 SUMMARY OF RECOMMENDATIONS

20.5.1 This Chapter is more meant to present a synthesized picture of the various issues which have been discussed individually in various other chapters and which have a bearing on crop production. Recommendations made in other Chapters are not repeated here ordinarily. Those arising from this Chapter are given below :

1. Appropriate research organisation is required to evolve diversified cropping systems in heavy rainfall areas instead of the mainly monocropping system with paddy that exists at present. Allied socio-economic problems and problems relating to soil conservation and maintenance of soil fertility will also have to be studied.

(Paragraphs 20.2.6 and 20.2.9 to 20.2.14)

2. Attention should be devoted to store water in deep valleys at appropriate places towards the end of the rainy season in heavy rainfall areas, in order to lengthen the cropping season.

(Paragraph 20.2.7)

3. In order to ward off the danger of water scarcity for irrigation of paddy during prolonged spells of drought shallow wells may be dug in every paddy field in heavy rainfall areas.

(Paragraph 20.2.8)

4. Seed material for high rainfall areas has to be produced elsewhere because of fast deterioration inherent in these areas.

(Paragraph 20.2.16)

5. Implements and machinery particularly suited to high rainfall areas will also have to be developed.

(Paragraph 20.2.16)

6. A farming system designed to cultivate crops in flood-free periods has to be developed for Assam and Bihar. The kharif crops of rice and jute must be either sown early in order to escape/withstand damage or the varieties should be such as to endure flooding (e.g., deep water rice).

(Paragraphs 20.2.17, 20.2.18)

7. Increasing use of forage crops in low rainfall areas in crop rotations or as leys is required to be effected.

(Paragraph 20.2.24)

8. In recognition of the importance of detailed crop planning in meeting the challenge of aberrant weather, as illustrated in the case studies mentioned in the text, similar analysis and contingent cropping

plans should be developed for all the 72 drought prone districts in the country and implemented as farmers' programmes for drought proofing of the areas.

(Paragraph 20.2.47)

9. In view of the available technology, any strategy for crop planning in drought prone areas in the country should include the basic practices described in the text as essential constituents of the package programme for implementation under a rational system of land utilisation.

(Paragraph 20.2.53)

10. Kharif fallows of Madhya Pradesh, which are at present utilised only for raising wheat or other rabi crops, could be utilised for growing crops in the south-west monsoon season too through suitable water management programmes.

(Paragraph 20.2.56)

11. Cultivation of pulses/leguminous crops in rotation or as intercrops is recommended in canal irrigated tracts for purposes of green manuring and maintenance of soil fertility.

(Paragraphs 20.3.7 and 20.3.8)

12. Weed and disease-pest control measures are specially needed to be developed for irrigated conditions and heavy rainfall areas.

(Paragraph 20.3.11)

13. Riverbed farming has to be developed as a distinct way of cultivation, specially for vegetables and melons. This has been a neglected sphere and, therefore, requires the attention of the scientists and developmental authorities alike.

(Paragraph 20.3.14)

14. Sewage farming utilising town effluents for irrigation should be developed to the maximum possible extent. Some of the expenditure incurred on this could be recovered through charges which can be levied on effluent irrigation and the balance, if any, could be treated as developmental expenditure.

(Paragraph 20.3.15)

15. Scientific investigations into the subject of multiple cropping and crop rotation in various parts of the country have yielded valuable data on new patterns of cropping suitable to the respective areas. There is now a pressing need to make a reappraisal of the various possibilities to evolve cropping systems for covering all kinds of soil, rainfall and irrigation conditions as obtains in every taluk. The cropping systems so determined should be put into operation through active extension efforts and there should be a machinery to assess the progress and to effect mid-course alterations according to need.

(Paragraphs 20.4.5 to 20.4.10)

APPENDIX 20.1

(Paragraph 20.4.6)

Proposed Crop Rotations for Different Regions of Bihar[1]

Region	Irrigated areas	Non-Irrigated areas	Flood affected/low land areas
1	2	3	4
(i) north Bihar Plain (a) terai area (comprising parts of Champaran, Muzaffarpur, Darbhanga and Purnea districts)	paddy-potato-jute paddy-rabi maize-jute paddy-wheat-jute paddy-wheat-paddy paddy-berseem paddy-sugarcane	paddy-paira (for low land) jowar+*meth*-oats+peas *marua* (Ragi) barley *aus* paddy-sweet potato	for flood affected areas of north Bihar plain flood resistant paddy-barley (FR 13A & FR 43 B) summer maize+*moong*+barley flood resistant paddy-summer maize for low lands of north Bihar plain deep water paddy (BR 14) sown in April *moong*+*cheena*+paddy deep water paddy-sugarcane (B.O.3)
(b) non-calcareous non-saline (districts of Saharsa, part of Purnea, Darbhanga, Muzaffarpur, Champaran, and northern parts of Monghyr and Bhagalpur)	paddy-wheat-paddy paddy-potato-paddy paddy *rabi* maize-paddy paddy-wheat-*cheena* paddy-wheat-jute paddy-potato-jute paddy-potato-summer maize paddy-mustard-*moong* paddy-barseem-paddy paddy-wheat-*moong*	*aus* paddy-barley+pea *aus* paddy-*sarson* paddy-paira (gram, linseed or *khesari*) jute-sweet potato groundnut-barley *marua*-barley+pea Jute-paddy	
(c) calcareous soil (major part of Saran, southern Darbhanga, Champaran and Muzaffarpur)	paddy-wheat-jute paddy-potato-jute paddy-wheat-paddy paddy-potato-paddy maize-wheat-moong maize-sugarcane+mustard maize-early potato-*moong* maize-*tori*-wheat-*moong* maize-berseem maize-potato-*cheena*	maize+tumeric+*arhar* tumeric+*arhar* maize+*arhar*-castor-*arhar*+castor maize-chillies maize-tobacco maize-sweet potato maize-*kajai*-wheat early paddy-wheat or barley marua-barley+pea	
(ii) south Bihar plain (comprising Patna, Gaya, Shahabad, major parts of Monghyr and Bhagalpur districts)	for light soils of upland- maize-wheat maize-potato-*cheena* maize-early-potato-late	for light soils of upland- maize-barley or gram maize+kalai-wheat (NP 852, K. Sona)	

1 1973—Symposium on Multiple Cropping, New Delhi, Indian Society of Agronomy.

1	2	3	4
	potato-summer vegetable maize-early potato-wheat-*moong* maize-tori-wheat-*moong*	Groundnut-wheat (NP 852, K. Sona) jowar + meth-linseed marua-wheat (NP 852, K. Sona) maize-linseed (T 397)	
	for heavy soils of low land— paddy-wheat-paddy aus paddy-potato-onion paddy-sugarcane *aus* paddy-wheat-summer vegetable early-paddy-potato-*cheena* *aus* paddy-winter maize paddy-berseem-*moong*	for heavy soils of low land— paddy-*paira* (gram, lentil, linseed, *tori*) paddy-wheat paddy-barley	
(iii) Plateau region (comprising Ranchi Palamau, Hazaribagh, Dhanbad, Singhbhum and Santhal Pargana districts)	for *tanr* lands (uplands)— maize-*kalai*-wheat maize + cowpea-wheat jowar-*kalai*-wheat or potato bajra + *kalai*-wheat or potato maize-potato-wheat maize-potato-wheat-*moong* for medium uplands- paddy (IR 8 or Jaya)-wheat paddy (IR 8 or Jaya)-potato paddy (Jaya)-wheat (sonalika)-paddy (Padma)— paddy (IR 8)-winter maize jute for seed-wheat paddy-wheat-*moong* for *don* lands (low lands)— early *aman* paddy (BR 34)-wheat late aman paddy (BR 8, T 141)- rabi vegetables or wheat jute for seed-potato-vegetables	for *tanr* lands (uplands)— groundnut-linseed maize + *arhar-arhar* rainy season potato-linseed marua-linseed jowar-ratoon *jowar* maize-kalai-sweet potato cotton + groundnut-cotton *gora* paddy-linseed maize-cowpea-linseed for medium uplands- *aus*-or early *aman* paddy-linseed (T 397) direct sown paddy (Padma)-linseed (T 397) for *don* lands (low lands)— early paddy-linseed (T 397) late aman paddy-*paira* paddy-gram	

21

FOODGRAIN CROPS

The crops included are : rabi cereals (wheat, barley, oat, rye and triticale), kharif cereals (rice, maize, jowar, bajra, ragi and other small millets) and various kinds of pulses, which provide staple food to the country's population. These crops occupy at present as much as 75 per cent of the total gross cropped area. Despite so much area under them, the country is forced from time to time to resort to imports of foodgrains. It is absolutely essential to do away with the imports in future, rather it should be possible to build up surpluses of such an order that exports become possible after meeting the country's food and industrial needs. There is no room for further increases in the total area under these crops because of the increasing demands with respect to other kinds of crops. The effective solution lies in improving yield standards by various means including examination of the possibilities of avoiding the variations in production due to vicissitudes of weather. The crops are examined in this chapter with this primary objective.

1 RABI CEREALS

Wheat

21.1.1 Northwestern parts of undivided India constituted the real wheat bowl for the country. The area under wheat was around 13.5 Mha and production 10 million tonnes in pre-partition days. The yield per hectare was of the order of 0.7 tonnes or 7 quintals (Appendix 21.3—Statement I). On partition in 1947, Indian Union was left with only 60 per cent of the total area in undivided India. The area was almost made up to pre-partition level and yield was even bettered slightly by 1960-61 (12.9 Mha and 0.9 tonnes/ha respectively). This was chiefly due to developments which took place in and around Punjab. Research efforts which made this achievement possible mainly related to conventional varieties. The position remained more or less static upto 1966-67. As a result of increase in area under new dwarf varieties and adoption on large scale of better agronomic

techniques including irrigation, the production in 1967-68 increased to 16.5 million tonnes raising the yield to 1.1 tonnes/ha. The upward trend in production and yield per hectare has continued since then. In 1971-72, the area and production were 19.1 Mha and 26.4 million tonnes respectively giving an average yield of 1.4 tonnes/ha. For statewise assessment, the averages of three recent years, viz., 1969-70 to 1971-72 pertaining to area, production, yield and irrigation are given in Appendix 21.3—Statement II. It could be seen that the core region responsible for 70 per cent of area and 74 per cent of production comprises Punjab, Haryana, Delhi, Uttar Pradesh and Madhya Pradesh flanked by Rajasthan and Gujarat on the west and Bihar and West Bengal on the east, each flank accounting for 9-11 per cent of area and 11 per cent of production. Jammu & Kashmir and Himachal Pradesh in the north account for 3 per cent of area and 2 per cent of production. Maharashtra and Karnataka in the peninsula account for about 7 per cent of area and 2.5 per cent of production. Yields in the main belt vary between approximately 1 and 2.3 tonnes/ha with the exception of Madhya Pradesh, which records only 0.78 tonnes/ha. Maharashtra and Karnataka have yields of the order of 0.5 tonnes/ha only.

21.1.2 The distribution of mean daily (maximum plus minimum divided by two) and mean daily minimum temperatures for January which is the coldest winter month in most parts of the country, have been depicted in Appendix 21.1—Map 1. Southern limit of the main wheat growing belt will be found approximately to correspond to 20°C mean isotherm and 12.5°C mean minimum isotherm. In Maharashtra and Karnataka, mean temperatures vary between 20°C and 25°C with pockets of 22.5°C or less here and there and mean minimum temperatures range from 12.5°C to 17.5°C. Mean daily temperature is a little less in December in these States when compared with January, though the difference is generally less than a degree. Wheat is a low temperature crop. There is a period of 4 months from mid-November to mid-March in the north, when it can experience cold conditions—December and January being the colder months with January as the coldest. Compared with this, the peninsula experiences just about 2 cold months between mid-November and mid-January with December being slightly colder, but the temperatures are not as low as in the north. Therefore, the crop in the peninsula hastens its life cycle. The same variety, which takes about 5-6 months in the north, will come to maturity within about 3 months when grown in the south. The plants are shorter in height and tillering is poor. Therefore, the yielding capacity of a variety decreases considerably. Besides temperature, wheat crop represents a resultant of three factors whose favourable interaction determines its ultimate success. These

are (a) June—October rainfall, (b) winter precipitation of November—February and (c) irrigation. Rainfall of the pre-sowing season determines the level of conserved soil moisture on which the crop can make a start or carry itself through. The rainfall of winter months exerts a direct beneficial influence during the growing season itself, but the amount of winter precipitation being very small, it does not have a decisive role in improving production beyond a certain point and wheat areas are found scattered over a wide range of rainfall distribution (Appendix 21.3—Statements III to V). Thus, the monsoon or post-monsoon rainfall by itself is not sufficient for optimum production. Ultimately, therefore, it is the extent to which irrigation can be provided to this crop which determines its yielding capacity.

21.1.3 Appendix 21.3—Statement II may now be examined against the background of irrigation. The crop is taken with irrigation to an extent of 29 per cent of area in Maharashtra and 9 per cent in Karnataka. The yield level is poorer than Madhya Pradesh in both (below 0.5 tonnes/ha), but this is understandable partly from unfavourable temperature conditions prevalent there. Otherwise, in the main wheat belt, it is really Madhya Pradesh's yields which are very poor. The yields of West Bengal are comparable with those of Punjab. Production trend in West Bengal gives an interesting picture. The area and production were of the order of 65,000 ha and 50 thousand tonnes between 1954 and 1956, giving an average yield of about 0.75 tonnes/ha. Then the area fluctuated between 1957-58 and 1964-65 and the yield levels generally remained below 0.7 tonnes/ha. A systematic progressive increase is observed thereafter as would be seen from the data presented below :

TABLE 21.1

Area, Production and Yield of Wheat in West Bengal

area . . thousand hectares
production . . thousand tonnes
yield . . tonnes/ha

Year	Area	Production	Yield
1965-66	41.2	34.0	0.83
1966-67	55.4	45.5	0.82
1967-68	79.0	71.1	0.90
1968-69	150.0	200.0	2.00
1969-70	240.0	400.0	1.67
1970-71	360.2	868.1	2.41
1971-72	500.0	1,152.0	2.30

21.1.4 The breakthrough attained in wheat production is ample proof of practical achievements of research. Compared with many other crops, there is no dearth of varieties or techniques in the case

of this crop. Also there is emphasis towards research on irrigated wheat. Scientific improvement does not seem to be a bottleneck insofar as wheat is concerned. The developmental activities have also not lagged behind in the case of this crop. This can be judged from the spread of high yielding varieties. The spread of high yielding varieties of wheat has far excelled the position of many other cereals. The area under high yielding varieties in the Punjab region is ranging between 50 to 70 per cent at present and in Uttar Pradesh, Bihar and Rajasthan it is ranging between 20 to 50 per cent. It is expected that the bulk of wheat area will be covered with new varieties in the course of next 10 years or so. Insofar as yields are concerned, it is claimed that, with the double and triple dwarf wheats and with the needed inputs, yields of 4 to 4.5 tonnes per hectare are possible in irrigated areas. Yields of the level of 6 to 7 tonnes per hectare have already been obtained by progressive farmers, Krishi Pundits and in National Demonstrations. Yields from unirrigated wheat can also be made to reach about 2 tonnes/ha (0.8 tonnes/ha is the present level in Madhya Pradesh) provided high yielding varieties are bred and appropriate growing techniques developed for such conditions. At present, (a) traditional varieties with limited yielding capacity are used in dry areas, (b) proper agronomy in terms of water conservation, correct method of sowing, seed rate adjustment, fertiliser application etc., are not fully followed and in fact very little or no fertiliser is applied and (c) control measures against pests and diseases are rarely adopted. These defects are required to be removed in order to achieve the indicated target. Moreover, Maharashtra and Karnataka in the Deccan also require attention. It is possible to increase wheat yields even in those States provided early maturing high yielding varieties are developed for the locally prevailing shorter and milder winter conditions. Similarly, suitable agronomic methods have also to be developed. The crop does not tiller properly in these latitudes. This can be compensated by high seed rate. The area in these States could be reduced a little, but the extent of irrigation could be increased in consonance with the available facilities.

21.1.5 It is estimated that about 15 Mha of wheat area could be irrigated in 2000 AD. Keeping in view this fact suitable area and yield targets have been worked out in Table 21.2 for different States. The chief features which emerge from the table are that by 2000 AD :

(i) the area will stand at 17.55 Mha, implying a marginal reduction from the present level of 18 Mha;

(ii) the irrigated area will become 85 per cent as against 53 per cent as at present; and

(iii) the average all India yield will work out to 3.64 tonnes per hectare, the total production being 63.81 million tonnes.

The calculations include the mountainous area of Jammu & Kashmir and Himachal Pradesh for the present, but the work so far done clearly points out that the Nilgiri and Palni hills in the south are the primary foci of infection of black rust and the Himalayas in the north for yellow rust. Either wheat cultivation has to be eliminated from such areas altogether or else these hills should be systematically saturated with wheat varieties resistant to the concerned rusts. In the latter case, a special surveillance service for this purpose will have to be organised in the hill areas so that appropriate measures for replacement of a variety can be taken no sooner it is found to develop susceptibility.

TABLE 21.2

Targets of Area and Yield of Wheat, 2000 AD

area . . . Mha
production . . million tonnes
yield . . . tonnes/ha

State	Total area		Irrigated area		Yield per hectare in 2000 AD	
	present	2000 AD	present	2000 AD	irrigated	unirrigated
Jammu & Kashmir, Himachal Pradesh . .	0.56	0.56	0.09	0.11	3.0	1.5
Punjab, Haryana, Delhi, Gujarat	3.94	3.94	3.19	3.74	4.0	2.0
Rajasthan, Uttar Pradesh, Bihar	8.49	8.00	5.43	7.50	4.0	2.0
Madhya Pradesh . .	3.36	3.00	0.53	2.00	4.0	2.0
Maharashtra, Karnataka .	1.25	1.00	0.30	0.50	3.0	1.5
West Bengal . .	0.36	1.05	0.03	1.05	4.0	2.0
Assam, Orissa, Andhra Pradesh . .	0.05	—	0.01	—	—	—
all-India	18.01	17.55	9.58	14.90		

21.1.6 In order to achieve maximum possible levels of production, a few precautions are necessary. Three of these are indicated below :

(i) Discouraging late sowing—With the availability of photo-insensitive early dwarf wheats, wheat is being sown very late which was not possible earlier with the conventional varieties. Wheat sown in the normal period (say, October 15—November 30) gives much higher yields than wheat sown late in the season and, therefore, departure from the optimum range of sowing dates has to be avoided. Extension workers should educate farmers duly in this regard.

(ii) Diversification of wheat varieties—India is in a vulnerable

position in regard to devastating and debilitating epidemics because of the very few varieties with very narrow genetic base which are under cultivation at present. Two varieties, viz., Kalyansona (or its red grained sister line PV 18) and Sonalika are most widely grown in all parts of India. In Punjab, 90 per cent of the HYV area was under Kalyansona or PV 18 in 1972-73. The same position exists more or less in other wheat growing States. The hills of north India, which form the foci of infection for yellow and brown rusts, also have large areas under Kalyansona and Sonalika. This unplanned cultivation of Kalyansona in the hills has led to the multiplication of races to which Kalyansona is susceptible. Continued cultivation of Kalyansona and Sonalika in the hills is fraught with grave danger. Experience in other countries with wheat, maize and other crops has clearly shown the need for diversification of genotypes for resistance to major diseases. Work has to be intensified to introduce diverse genes for resistance in the commercial wheat varieties.

(iii) Storage losses in cereals account for 6—8 per cent of the total quantity. These have to be minimised and in this work, control of storage pests will go a long way because the major toll is taken by them.

21.1.7 It has to be noted that much of the work that has been done on wheat has related to the common bread wheat, *Triticum aestivum*. Other wheats, i.e., the maceroni wheat (*durum*) and the emmer wheat (*dicoccum*) still need considerable attention. While *durum* has many uses common with *aestivum*, it is more suited for the preparation of noodles, spaghetti, samolina and *suji*, *T. dicoccum* is specially meant for granular preparations and the south Indian dish-*uppuma*. Some studies have shown that dwarf *durums* utilise water more efficiently than *aestivums* and, therefore, dwarf *durums* offer much scope where water is a critical factor. *Durum* and *dicoccum* are worth trying for the southern conditions. In 1971-72, the production of bread was 198 thousand tonnes and that of biscuits 146 thousand tonnes. The milling, baking and confectionary industries are rapidly developing in India. The bread industry has so far been dependent on imported wheat from the USA, Canada, Argentina and Australia. It is often said that this foreign wheat is better for milling and baking purposes than the Indian wheat. Although some good quality Indian wheats are available for these purposes, yet further work also has to be done. Insofar as the existing suitable varieties are concerned, arrangements for their cultivation have to be made specifically for industries.

Barley

21.1.8 Barley is a hardy cereal of rabi season. It is raised in spring in areas like Ladakh and Lahaul. It can give reasonable yields even under low fertility conditions. It is tolerant to saline and alkaline conditions and is, therefore, preferred on such soils. Best lands with good irrigation facility are allotted to wheat; barley comes only next in preference both with regard to choice of land as well as irrigation. When wheat itself is taken on inferior soils, barley is put as a mixture with it. Mixed crop of barley is as popular in the north as the pure crop and for this reason irrigation given to mixed crop for wheat gets counted for barley too. Therefore, it is difficult to sort out how much of the pure barley crop really gets irrigated. Barley has a shorter growth period as compared to wheat. Poor farmers living hand-to-mouth and facing deficit between the harvests of kharif cereals and wheat resort to barley cultivation. Barley growing areas are demarcated in Appendix 21.1—Map II. Barley cultivation will be found to be confined to the north of latitude 24°N whereas a reference to Appendix 21.1—Map I would indicate that wheat extends much down south. Wheat can thrive under warmer conditions than barley, oat or rye. Appendix 21.3—Statement VI gives the average area and production of barley (1969-70 to 1971-72). Uttar Pradesh alone accounts for 53 per cent of area and production. Rajasthan comes next with a share of about 20 per cent. The Punjab region (including Haryana and Delhi), Bihar and Madhya Pradesh each account between 6 to 10 per cent of area and production. All these States put together account for 95 per cent of area and production. Fluctuations in barley area between the years 1965-66 to 1972-73 are presented graphically in Appendix 21.2—Figure I. Except for Madhya Pradesh, a declining trend in area is noticeable. It appears to be due to preference to a crop like wheat, which has been receiving particular attention in the recent past. The following facts have to be reckoned with in this connection :

(i) As already stated above barley becomes available in the time interval between the harvests of kharif cereals and wheat and, therefore, has an advantage for the poor people. It has cooling property and, therefore, is very suited for the northern Indian summers. It is popular in the form of *chapatis* as well as ready-to-eat paste called *sattu*. For these reasons, barley would continue as staple food in certain areas.

(ii) Barley is useful for feeding to livestock too. It is acceptable for milch, meat or draft animals equally well. When impetus is to be given for the production of livestock

feeds of all kinds, the role of barley would assume greater importance.

(iii) Barley has also some important uses in industry. Barley grain is processed into malt. The major uses of malt in industry are in the manufacture of beer, alcohol and processed foods.

21.1.9 The above mentioned reasons are sufficient to show that barley cultivation has to be encouraged. Since it is a hardy crop, emphasis has to be laid on raising barley under unirrigated conditions. Barley is a salt tolerant crop and suits the salt affected areas. However, irrigation is very necessary in such situations. An area of 1.30 Mha can be earmarked for irrigated barley. There is a limit to improving yield under unirrigated conditions and, therefore, some increase of area under this crop seems possible and desirable. The present area under barley is 2.58 Mha. This area can be raised to 5.50 Mha including 0.34 Mha of saline and alkaline lands. The wheat area has been suggested to be reduced by 0.46 Mha, which represent marginal and unirrigated lands. This area can be transferred to barley. Land use statistics for rabi and kharif in Uttar Pradesh, Bihar, Punjab and Haryana will show at a glance that lands are kept fallow in either season. It should not present any difficulty in accommodating the additional barley area in these fallows. Experimental and demonstration results have shown that the semi-dwarf types, which are grown under irrigated conditions, are capable of giving 4.5 to 5.5 tonnes per hectare. Assuming even a moderate yield of 3.5 tonnes per hectare on an average from irrigated land, the proposed irrigated area of 1.3 Mha will give a total outturn of 4.55 million tonnes. Improvement under dry conditions can lead to increasing the existing yield by about one and a half times even on modest considerations (i.e. 1.5 tonnes/ha) and, therefore, the remaining area of 4.2 Mha will give a production of 6.30 million tonnes @1.5 tonnes/ha. Thus, the total production in all, which can be achieved by the close of the century will be 10.85 million tonnes.

21.1.10 In research programmes, the development of semi-dwarf fertiliser responsive varieties has engaged some attention, because the varieties in vogue have been mostly tall, weak-strawed and lodge even under ordinary fertility levels. A semi-dwarf type has already been released for Rajasthan. Semi-dwarf varieties, however, need irrigation. This handicapped their spread in unirrigated areas. The corn leaf aphid has continued to be a serious pest for nearly all varieties, despite efforts to identify insecticides or sources of genetic resistance. Breeding for resistance to yellow rust has made some progress. Diseases like stripe rust, spot blotch, net blotch, stripe disease, loose smut and molya disease still require effective solution. Molya disease has recently

assumed serious proportions on the light soils of Rajasthan and Haryana. All such pest-disease problems need attention. Even though some efforts have been made to develop agronomic schedules for unirrigated conditions, such work requires to be intensified much more in future. It has to cover breeding as well as plant protection programmes in order to improve yield and nutritional quality under dry conditions. Varieties and techniques suited to saline or alkaline lands have also to be developed. Some other aspects, which will need attention in future, are listed below :

(i) Lodging-resistant varieties should be developed.

(ii) Breeding efforts are also needed to evolve suitable varieties for specific purposes e.g., two-row types are necessary for brewing because these have the necessary physical and chemical characteristics for high quality malt.

(iii) Barley is consumed primarily as food, particularly in lower income group. Therefore, improvement of nutritional quality deserves attention. Recently, 'Hily' gene in variety Hiproly has been discovered, which improves lysine content. This variety also has high protein content. A collaborative programme between breeders and biochemists should be developed to utilise 'Hily' gene.

(iv) Reduction in crude fibre content by breeding varieties which have less husk is necessary to improve digestibility. Hulls also foster digestive difficulties to human beings and monogastric animals. Therefore, evolution of hull-less types will improve the food as well as feed value of barley. At present hull-less types yield 20—30 per cent less than normal hulled types. This drawback has to be removed.

(v) Selection for increase in total liquid content and its increased concentration in embryo also needs attention, because lipid provides 2.25 times more energy per unit weight than starch.

Oat

21.1.11 Oat grain is used in preparing breakfast food. Most of this food is in the form of rolled oats. Rolled oats and oatmeal are rich in protein, fat and energy value and provide calcium, phosphorus, iron and thiamine also. About three or four concerns in India are engaged in manufacturing this kind of material from oats. Oats have also their utility as feed for horses and are excellent for breeding animals and young stock. Their value as feed for various classes of livestock, especially race horses, is due to the fact that they are not only quite bulky but in addition are fairly high in protein content

(17-18 per cent). Before Independence, there was a good demand for oat grain especially for meeting the requirement of Army Veterinary Corps. Sikandrabad (Bulandshahar, Uttar Pradesh) was an important market centre for oat grain. In recent decades, however, the demand from the army has declined, since oats are now being fed only to special breeds of horses. Horses and mules are in general fed on other grains like barley and gram. The requirements of the army are being met now from the produce from their own farms. Even in general, the reliance is more and more on the internal production because of newly bred better varieties of Australian stock. The imports, which were 880 tonnes in 1964-65, have come down to 200—300 tonnes in recent times.

21.1.12 Oat is a good rabi fodder crop and is amenable to late sowing and such late sown crop can supply green fodder up to the months of April and May even. The oat fodder has generally been popular in the wheat belt of the country, especially in the Punjab region and adjoining parts. Its fodder has been generally used for feeding to breeding horses and tonga ponies. However, this fodder has a great potential in the future programmes of dairy development also, because this along with lucerne and berseem is going to be the major proteinous green fodder in the northern areas. In this context, oat development has an important place and a substantial area has to be allotted to it, but this will come out of the total area shown under fodder crops in Chapter 25 on Fodder Crops. The present discussion is kept confined only to grain aspect. Data on area and production of grain crop are not available. This is a high water requiring crop, because of which not much area can be put under it for grain purposes, but even then an area of 0.5 Mha can be earmarked for it in the north within the wheat belt in order to meet the increasing demand for breakfast food. This allocation is subject to change on the basis of factual position when statistics on area and production become available and its food demand gets stabilised. Assuming an yield of 4 tonnes/ha with improved technology, a production of about 2 million tonnes can be expected from 0.5 Mha.

21.1.13 Scientific work on breeding of improved varieties of oats was earlier aimed at producing good quality green fodder. Work in this direction was done mainly at two stations : (i) Botanical Section of the Imperial Institute of Agricultural Research, Pusa (now IARI, New Delhi) and (ii) Fodder Research Station at Sirsa of the former Punjab (now in Haryana). Improved varieties did not spread much because of lack of seed multiplication arrangements. In more recent years, particularly during the period 1961—72, the Division of Plant Introduction at the IARI has been testing a number of improved varieties introduced from Australia, USA and Europe. As a result of

this work, two varieties 'Kent' and 'NP 101' (this material was received as a breeding line from Australia) have been found adaptable to north Indian conditions. The former is good both for good quality grain and green fodder. The latter, an early ripening dwarf variety, is recommended only for grain production. The National Seeds Corporation is now multiplying and distributing seeds of these two varieties. Very little work has been done on agronomic and plant protection practices. It is necessary that due attention is given to this crop in researches. As the crop is going to be of local importance only, it will be sufficient that the central research institutes and the agricultural universities located in the northern parts of the country include this crop in their normal research programmes along with crops like wheat and barley. Breeding of short straw varieties capable of withstanding lodging and responding to high doses of fertilisers and improvement in grain quality for use in the processing industry are some of the problems which should receive attention. It is desirable to aim for low percentage of hull in order to improve digestibility (oat grain has usually 25 per cent of hull).

Rye

21.1.14 Rye crop is not of any economic significance in India and no figures are available regarding its area and production. It is grown by a few farmers here and there in the upper ranges of Himalayas, e.g., Chini, Lahaul and Spiti of Himachal Pradesh. Rye cultivation in the lower hills or the plains in India is practically absent. Because of its limited value in Indian agriculture, no work on the improvement of this cereal has been done. Rye serves as a host for the ergot pathogen *Claviceps purpurea.* It is grown for producing ergot for medicinal uses in some Government farms in Jammu and Kashmir and Assam. We do not expect Rye cultivation to assume any significant proportions even in future.

Triticale

21.1.15 Triticale is a man-made cereal derived from crosses between wheat and rye. Although work on triticales is carried out in a number of countries, the main ones are Canada, Mexico and Hungary. Work on the development of triticale in Canada was initiated in 1954. Breeding work was taken up in 1958 and the first yield trials were conducted in 1961. The first commercial variety of triticale was released in 1970. Triticale programmes in Mexico and Hungary were initiated around 1964. The area under this crop in Canada and Hungary is of the order of 20,000 hectares. Triticale can fit into

soil types where cultivation of wheat is not possible or remunerative and used for (a) preparation of both leavened and unleavened bread, (b) breakfast cereal, (c) cattle and poultry feed, (d) fodder and (e) distillation of alcohol. The greatest interest in triticales is due to their high protein and lysine content. Certain varieties of this new cereal have protein content up to 21 per cent and a lysine content up to 4.5 per cent. The bread-making properties of many triticales are poor at present.

21.1.16 Although many triticales have been produced at several centres in the world, many problems still remain to be solved. These problems are indicated below :—

(i) Partial sterility : This has been the major problem in triticale and has been attributed to the interaction of wheat and rye genotypes.

(ii) Shrunken endosperm : The poor development of the endosperm is a major problem in triticale breeding. As a result of this, the grain is shrivelled and its test weight is reduced.

(iii) Lodging : Another serious limiting factor in triticales has been their susceptibility to lodging on account of their tall and weak straw. In recent years, dwarf triticales have, however, been produced in Hungary and Mexico using the dwarfing genes of Tomthumb and Norin wheats.

(iv) Adaptation : The present varieties of triticales are sensitive to changes in latitude. To make them acceptable, it is essential to develop triticales with wider adaptation to a variety of climates.

(v) Disease susceptibility : Many of the present-day triticales are susceptible to one or the other of the diseases that attack wheat and rye. These diseases are the rusts, ergot and bacterial disease caused by *Xanthomonas translucens*. In addition to these, species of *Alternaria* and *Fusarium* also attack the triticales.

(vi) Grain toxicity : There are at least three sources of toxic compounds in triticale grains, viz., (a) ergot which produces ergotin, (b) fungi like *Alternaria, Aspergillus* and *Fusarium,* which usually attack seed during maturation under humid conditions and (c) organic compounds, resordinols, within the developing seed. Varieties of triticale differ in the production of these toxic compounds.

(vii) Lack of seed dormancy : Many of the triticales lack seed dormancy, as a result of which seeds germinate even on spikes at the time of maturation.

21.1.17 Work on triticales was taken up very recently at the

IARI, Jawaharlal Nehru Krishi Vishwa Vidyalaya (Indore Centre), Punjab Agricultural University, Ludhiana and Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. Material developed in Mexico and supplied through the International Triticale Yield Nurseries was tried for its performance under Indian conditions. Most of this initial material belonged to the Armadillo group. The different types were tall, weak-stemmed and susceptible to rusts. The grains were ill-developed. Trials were conducted with this material all over the country under the All-India Coordinated Wheat Improvement Project. None of the triticales performed well and in fact, they gave on an average 60 per cent of the yield of the standard check variety, Kalyansona. Boron, which according to the work in Russia improved the grain filling in triticales, was sprayed in different concentrations on the plants. Although there was slight improvement in grain filling, it was not appreciable to warrant its widespread usage. Some triticales were tried under rainfed conditions for comparing with wheat and barley. Their performance was better than that of wheat but that of barley was the best. Some triticales were tried in the high elevations of the Himalayas by the Pantnagar University. The results indicate that triticales may hold promise in the hills, particularly under low fertility or rainfed conditions. Since triticales are highly resistant to powdery mildew, which is widely prevalent in the hills, they may prove useful in such areas. This advantage, however, is offset by their susceptibility to ergot and other toxins. Triticale programmes at Delhi, Indore, Pantnagar and Ludhiana now use wide range of wheat and rye germplasm to develop varieties with desirable characteristics. Dwarfing genes of wheat have been successfully incorporated into the triticales. Grain fertility has also been improved in some of the new types. Although some progress has been made in overcoming grain shrivelling, yet more work has to be done before the triticale grain can be made acceptable to consumers. In short, from many points of view this crop need not be considered for future planning. It is still in an experimental stage.

2 RICE

21.2.1 Rice is the main cereal of the country. Its area and production represent respectively 80 and 40 per cent of all the cereals and pulses together. Despite its importance, the country (after separation of Burma) has never been in a state of self-sufficiency in rice; in fact there have been frequent imports from other countries. Besides,

its prospects are often subject to the vagaries of rainfall. If the crop has to depend solely on rainfall, a monthly amount of not less than 30 cm pm (corresponding to an average rate of 1 cm per day) spread over at least three consecutive months could be considered minimum. However, a reference to Appendix 21.1—Map III and Appendix 21.4—Statement I would indicate that the regions satisfying this criterion are confined only to the northeast or west coast and the rice areas there constitute but a small fraction of the total all-India area (9 per cent in the former and 5 per cent in the latter). In addition to limited area, the north eastern parts chronically suffer from devastating floods. There is, of course, a vast tract comprising the States of Uttar Pradesh (hills, *tarai* and eastern districts), Bihar, West Bengal (Gangetic), Madhya Pradesh and Orissa which has more than 30 cm of rainfall per month in two consecutive months of July and August and 20 to 30 cm in September (Appendix 21.1—Map IV). The rice area in this tract represents 45 per cent of the all-India total, but the advantage of near favourable conditions of average rainfall is diminished because of the high variability resulting in occasional droughts or floods.

21.2.2 The rainfall conditions over most parts of the country are not ideally suited for rice cultivation. Yet the crop is spread far and wide. The farmer grows this crop in the low lying areas or even uplands and though the amount and distribution of rainfall is inadequate an attempt is made to maintain the crop through irrigation. More than one crop is taken in many parts. There are two factors which determine the number of rice crops taken in a year. Low temperatures preclude the possibility of winter sown crop in north western India. Limitation of rainy period to only four South West (SW) monsoon months precludes any dependence on rainfall—sufficient or insufficient—for taking the crop in other months in Uttar Pradesh, most of Bihar, Madhya Pradesh, Gujarat, Maharashtra, parts of Andhra Pradesh and Orissa. In contrast with these parts, the eastern and southern regions comprising Assam, West Bengal, coastal Orissa, coastal Andhra Pradesh and its areas adjoining Tamil Nadu, most of Karnataka, Tamil Nadu and Kerala receive rainfall of 10-20 cm pm in four to eight consecutive months starting earlier or going over later than the SW monsoon months. Taking advantage of this rainfall and resorting to irrigation for additional needs, some farmers in these parts take two to three crops (Appendix 21.1—Map V).

21.2.3 It is difficult to study the area and production of rice on a common all-India basis because in some parts this crop is grown only once, while in others it is grown more than once in a year. The commonly known agricultural seasons of *rabi, kharif* and *zaid* are

based on the commencement of sowing. But the rice crop grown at different times is classified in many parts according to the period in which its harvest falls, e.g. :

(a) autumn—harvesting in October $\pm$ 15 days (aus)

(b) winter—harvesting in December $\pm$ 15 days (aman)

(c) summer—harvesting in April $\pm$ 15 days (boro)

The officially reported all-India statistics for this crop are according to autumn, winter and summer harvests. In this system, crops with widely varying dates of sowing get pooled together under each category (Appendix 21.5—Statement I). This system works fairly satisfactorily in the eastern and southern parts, but in the northern and central parts there is difficulty in interpretation. An early duration kharif crop gets classified under 'autumn' and the long duration kharif crop under 'winter', whereas both of these experience the common weather of July-September which influences their growth alike. Secondly, it gives an underestimate of the size of the total *kharif* crop. In order to obviate these difficulties and reduce the scatter of dates of sowing in each category, the all-India statistics have been rearranged according to three broad periods of sowing, viz., February-May, June-September and October-January with an assumption that the months of April, July and December approximately represent the peak sowings in each period respectively. The position is fully explained in Appendix 21.5 and rearranged data presented in Statements II and III thereof. A reporting system based on two-monthly sowing periods gives the maximum coverage of the crop. However, an experimental project is necessary to determine the most feasible arrangement. A revision of the reporting system is also called for because of the introduction of many new varieties, whose growth behaviours are different from those of traditional ones. Meanwhile the conclusions emerging from the statistics given in Appendix 21.5 are mentioned below :

(i) The average area under rice during 1969-70 to 1971-72 was 37.5 Mha. The proportion of different crops was as follows :

February-May sown crop	15.8% of all-India
June-September sown crop	79.5% of all-India
October-January sown crop	4.7% of all-India

(ii) The mono-season belt accounts for 46.4 per cent of all-India area (of which Uttar Pradesh, Bihar and Madhya Pradesh account for 38.3 per cent), whereas the multi-season belt accounts for 53.6 per cent (of which Orissa and West Bengal account for 12-13 per cent each and North Eastern States, Andhra Pradesh and Tamil Nadu 7-8

per cent each).

(iii) The all-India yield of rice is 1.11 tonnes/ha. Rice production is throughout referred to in terms of cleaned rice, which is two-thirds of paddy. Punjab and Haryana yields are 150-160 per cent of all-India. The monsoon rainfall cannot support this crop at all, in these States. It is supported fully by irrigation. The way rice cultivation has been catching up in these States is shown in Appendix 21.4—Statement II. Rajasthan yield is also around all-India average, but it would increase further with the increase of irrigation facilities. There is a feeling that non-consumer areas like Punjab, Haryana, Rajasthan, Garhwal hills and adjoining plains of Uttar Pradesh can be encouraged to grow superior quality rice for exports. Rice area should be stabilized at the current level and not extended to ensure irrigation supply. The lands which could be utilized for this purpose should be the low lying ones or those which suffer from salinity and alkalinity.

(iv) Uttar Pradesh, Bihar and Madhya Pradesh record the poorest of yields, around 70 per cent of all-India. Their main problem is that July and August are the only two months of adequate rainfall for this crop. Even in these months there are spells of excessive rainfall causing serious drainage problems and floods in east Uttar Pradesh and Bihar and periods of drought. June rainfall is low and hence the crop is mostly transplanted in July. September rainfall is again less, because of which the crop suffers for want of water at a crucial time in its development. Thus, there are the twin problems of management of excess water in July and August and supplemental irrigation during breaks in July-August and in September. Water needs between July and September can be met easily if excess rainfall could be suitably stored. On the crop side, high yielding varieties of 90 to 120 days' duration will prove ideal for these States, because then the peak growth and development process can easily finish by the end of August for a June transplanted crop (later part of June) provided this is made possible by making available irrigation facilities in this month or by September end for the July transplanted crop. The observations about the three States apply to all the areas covered by the SW monsoon, where July and August are the only months

of dependable rainfall. If these problems could be solved, there is no reason why the crop cannot perform much better.

(v) Gujarat and Maharashtra are also monocrop areas served by the SW monsoon. Gujarat has about 1.3 per cent of all-India rice area and Maharashtra 3.6 per cent. Out of 1.4 Mha of rice area in Maharashtra, about half a million hectares are in the Konkan coastal belt. Konkan as well as the Gujarat coast have better rainfall conditions than the interior areas. In an overall assessment, both these States are about the normal in crop performance as revealed by the averages of 1969-70 to 1971-72. Otherwise, Gujarat yields have been usually around 80 per cent of all-India in some previous years.

(vi) North Eastern States, West Bengal and Orissa raise three crops. The area and yield levels of each of these crops are indicated below :

	sowing period		
	Feb–May	June–Sept	Oct–Jan
(a) area under each crop as per cent of overall State rice area			
North Eastern States . . .	35	62	3
West Bengal	16	80	4
Orissa	12	83	5
(b) yield of each crop as per cent of all-India yield			
North Eastern States . .	73	96	103
West Bengal	95	110	247
Orissa	49	80	198
(c) yield of each crop as per cent of overall State yield			
North Eastern States . .	83	109	117
West Bengal	84	97	217
Orissa	60	98	241

(vii) The monsoon crop continues to remain the main crop in these parts, but its proportion varies, which is determined more or less by the early occurrence of pre-monsoon

showers. Early pre-monsoon showers prompt the farmers to go in for a Feb-May sown crop (usual period of sowing being April or May). Assam and other adjoining North Eastern States have as much as 35 per cent of area under this crop. Even in West Bengal and Orissa, it is up to about 15 per cent. In North Eastern States early floods may occur even in June. On the other hand, West Bengal and the North Eastern States have to face heavy rains and floods in the monsoon season. Due to these factors, the performance of their pre-monsoon and monsoon crops does not rise as high as it should be.

(viii) Orissa's performance of the Feb-May and June-Sept sown crops is worse. Just like Uttar Pradesh and Bihar, Orissa with two months of July and August with dependable rainfall has similar problems and performance of its monsoon crop. Because of the 5-10 cm rainfall of May and expectation of canal water in the delta area, farmers in this State go in for a pre-monsoon crop and sow it around April. But due to insufficient rains and inadequate canal water the crop suffers. Moreover, there is rain at harvest time. This crop should be given up and efforts concentrated on improving the yields of the monsoon crop. Water saved from the summer-sown crop can prove useful in raising nurseries for early transplanting of the monsoon crop.

(ix) North Eastern States, West Bengal and Orissa receive some rainfall up to October. This proves helpful for their October-January sown crop, which occupies about 3 to 5 per cent of the rice area. The performance of this crop is the best in Assam, West Bengal and Orissa. The growing season is free from floods and the early growth can rely to some extent on the soil moisture conserved from the rainy period. The crop growth in a cloudless period, favourable for increased photosynthesis and better production. As this season has many technical advantages, it needs to be considered seriously as how best to increase irrigation facilities from November onwards and put more area under this crop. All possible efforts have to be made to harness the rain-water of the earlier period for this purpose. When this has been done, the rice area could be adjusted in the following proportions :—

	per cent of overall State rice area under the crop sown in		
	Feb-May	June-Sept	Oct-Jan
North Eastern States . .	20	60	20
West Bengal	10	80	10
Orissa	5	80	15

The varieties for the Feb.-May sown crop could be of 90 days' duration, for June-Sept. of 120 days' and for Oct.-Jan. sown crop of even 150-160 days' duration.

(x) Karnataka, Andhra Pradesh, Tamil Nadu and Kerala are the other four States which take more than one crop. Their position is indicated below :—

	sowing period		
	Feb-May	June-Sept	Oct-Jan
(a) area under each crop as per cent of overall state rice area			
Karnataka	..	92	8
Andhra Pradesh	37	40	23
Tamil Nadu	77	21	2
Kerala	45	44	11
(b) yield of each crop as per cent of all-India yield			
Karnataka	..	168	167
Andhra Pradesh	138	123	129
Tamil Nadu	167	180	170
Kerala	122	130	177
(c) yield of each crop as per cent of overall state yield			
Karnataka	..	100	99
Andhra Pradesh . . .	106	95	100
Tamil Nadu	98	106	100
Kerala	93	99	134

(xi) Karnataka takes primarily the June-Sept. sown crop. It also goes in for the Oct.-Jan. sown crop to an extent of 8 per cent. The rainfall in parts other than the coastal area is never sufficient for the crop and reliance on irrigation is almost hundred per cent. The performance of both the crops is satisfactory.

(xii) Andhra Pradesh experiences rainfall during the monsoon season as well as in subsequent months, but the amounts

are insufficient to sustain any of the three crops. Reliance on irrigation is hundred per cent. The yields are better than all-India average of the three crops, the performance of Feb.-May sown crop is 138 per cent of all-India yield. June-September sown crop gives only 123 per cent of all India yield, because drainage and pest problems are known to be acute in this season.

(xiii) Tamil Nadu concentrates on two crops, viz., Feb.-May and June-September. Rainfall is not sufficient for either of the two crops. The crops are fully protected by irrigation and the yields are very good (170-180 per cent of all India).

(xiv) Kerala has equal area under the pre-monsoon and monsoon crops because of the prevalent rainfall distribution. Its reliance on rainfall is more than in most other States, yet protective irrigation accounts for about 50 per cent of the area. The performance of the crop is above the all-India average.

21.2.4 Till about 1950, only the *indica* varieties prevailed which were not highly responsive to fertilisers. The Central Rice Research Institute (CRRI) was established at Cuttack in 1946. An international cooperative project aimed at hybridisation of fertiliser responsive *japonica* types with the *indicas* was initiated at this Institute in 1950 with financial assistance from the Food and Agricultural Organisation (FAO) of the United Nations and the Indian Council of Agricultural Research (ICAR). This project ultimately led to the identification of two promising varieties, viz., ADT 27 in India and Mahsuri in Malaysia. Even then, the transfer of fertiliser responsiveness on the scales comparable with *japonica* types could not be effected fully. On the side of better methods of crop production, the Japanese method of rice cultivation was also introduced in the country towards the early fifties. It mainly comprised seed selection and application of heavy doses of fertilisers combined with better cultural practices, but as most of the varieties were not fertiliser responsive, the introduction of better agronomic technique also did not have any significant impact on rice production of the country. Even so, the limited success due to the introduction of Japanese method of rice cultivation was a step forward. A bilateral agreement was entered between the Governments of India and Japan for the establishment of Indo-Japanese demonstration farms in different States. In each of the demonstration centres, a few Japanese technicians were based and were charged with the responsibility of demonstrating the potentials of superior cultural practices.

This brought about an awakening for the adoption of seed selection resulting in low seed rates and good cultural practices. The turning point came with the introduction of the dwarf rice variety—Taichung (Native) 1—from Taiwan through the International Rice Research Institute (IRRI) in 1964. In order to create a mass appeal for the new varieties, a Minikit programme has been started since 1972, which envisages distribution of small quantities of seed (1 to 2 kg) to a large number of farmers, approximately 500 per district, with an understanding that they would grow the new variety in an area of approximately 1/25 hectare side by side with their usual plots of traditional rice varieties. Smallness of area recommended for new varieties under this Minikit Programme improves acceptance by farmers to test new varieties and simultaneously makes it possible to distribute seed among a large number of farmers. The all-India coverage under high yielding varieties was 20 per cent in 1971-72. Statewise position is given in Appendix 21.4—Statement III.

21.2.5 Recent advances in rice crop improvement have annulled to an extent the association between tropical environment and low yield, good grain quality and low yield, and high levels of resistance to pests-diseases and low yield. To begin with, the dwarf type of high yielding varieties were mostly of medium duration. Early varieties of this type needed for rainfed areas and pre-flood and post-flood periods of cultivation did not exist. There were no late varieties needed for low lands or areas of heavy rainfall. This situation has completely changed now with the availability of a wide range of choice among the varieties, which mature as early as in 100 days to those that mature as late as in 160 days under transplanted conditions. Generally early maturing varieties do not come on par with late maturing varieties in outturn in absolute terms. However, such a comparison is not strictly valid. What should be attempted is to reduce the performance to yields per unit time as well as per unit of water consumed. Such information is not readily available to farmers for making their choice. It will be better if breeders provide this information in future as a routine while releasing varieties. Notwithstanding this handicap, it can be safely assumed that, if this test is applied even to the existing varieties, many of the early maturing ones will fulfil the desired expectations.

21.2.6 Besides the release of high yielding varieties, many factors have now been identified which affect tillering, e.g., poor incorporation of basal fertiliser, deep transplantation, planting old seedlings, inefficient top dressing, deep water and deficiency of phosphorus and zinc. Their correction could mean better yields. On manuring, it was felt earlier that a good part of programmed nitrogenous fertilisers (to the

extent of 50 to 75 per cent) was necessary as a basal dose for the photo-insensitive heavy tillering, early maturing and high yielding varieties, but it is felt now that for the dwarfs, split application of nitrogen is highly beneficial under all conditions. If a good part of nitrogen is applied in the very beginning, much of it is lost in the process of water management. It is, therefore, safe to make a few applications of nitrogen so as to synchronise with the stages of active uptake by the plants. The magnitude of increase in efficiency of added nitrogen with split applications is found to be approximately 30 per cent under transplanted and 50 per cent under direct seeded conditions.

21.2.7 On plant protection side, the emphasis in the past has usually been on prophylaxis. However, current researches are aimed at determining the economic thresholds for the incidence of pests and diseases such that the plant protection could be profitably programmed at the time when it is most rewarding rather than on the basis of prophylaxis. The traditional varieties were susceptible to stem borer and blast. In contrast, most high yielding varieties exhibit a high level of tolerance to blast disease, but they show greater susceptibility to such diseases and pests which were considered of minor importance earlier, e.g., sheath blight, false smut, *Helminthosporium*, tungro virus, leaf and plant hoppers and leaf folders. For this reason, work on them has to be intensified.

21.2.8 Grain yields secured with the dwarf rice varieties at the All-India Coordinated Rice Improvement Project Centre could range from 7 to 15 tonnes per hectare. The data from single crop demonstration in Rajasthan have also shown a maximum of 15 tonnes/ha. In West Bengal, the demonstration plot yields have been of the order of 6 tonnes/ha. The credibility gap between these attainments and the actual obtainable yields over large areas is too great. The maximum of yield in the country is of the order of 2 tonnes/ha and the all-India average is only 1.11 tonnes/ha. There has been no dearth of research efforts, but as has been seen, the conditions under which rice is grown are so varied from place to place that one coordinated system cannot be sufficient to answer the needs of all kinds of situations. It will be good to try a regional system of coordination for this crop. Considering the peculiarities of this crop, each region should be independent and self-sufficient by itself in research as well as extension efforts. Each region should have its own research institute of all-India status. The overall all-India coordination and related problems could be looked after by the CRRI in collaboration with these institutes. On extension side, the Ministry of Agriculture and Irrigation can develop a suitable regional machinery by involving the State Departments of Agriculture.

The regions could be (a) Jammu & Kashmir, Himachal Pradesh and West Uttar Pradesh Hills, (b) Punjab, Haryana, Delhi and Rajasthan, (c) Gujarat and Maharashtra (excluding coast), (d) Uttar Pradesh, Madhya Pradesh and Bihar, (e) West Bengal and Orissa, (f) North Eastern States, (g) Karnataka (excluding coast), Andhra Pradesh and Tamil Nadu and (h) Kerala, coastal Karnataka and Maharashtra. Important problems of paddy cultivation are mentioned below :

(i) Hills—The need is for evolution of high yielding varieties with some degree of cold tolerance and blast resistance coupled with early maturity.

(ii) West coast from Kerala to Gujarat—Rice is mostly taken here in the valleys of coastal alluvial strips. Kerala gets rainfall for 9-10 months, while Kanara and Konkan areas for 4-5 months only. Broadly speaking, late and medium high yielding varieties are needed for these areas. In these parts, water and soil management is particularly important. The slope of the Ghats towards seaside is comparatively steep. Water rushes down the hills and flows out rapidly into the sea. In this process, much of it is lost unused and shallow soil is washed out or leached of the soluble ingredients. Harnessing and guiding of water in an appropriate manner will solve these problems and thus give an altogether new orientation to paddy cultivation. This problem cannot be solved by individuals in a sporadic manner but requires the attention of planners and engineers. Agronomic and water management practices which can improve soils under leached out conditions are also required.

(iii) Sub-Himalayan West Bengal and North Eastern States—Major problem of this region is poor water control. Many areas remain inundated during kharif and are subject to frequent flooding. Even when land in low lying areas is fit for cultivation, the available high yielding varieties have not been found suitable because of late maturity. There is also the problem of topography. Even in the same locality, varieties of different durations are needed depending upon the contour of the land. In the uplands, early maturing varieties (approximately within 90 days' duration) are necessary or else the crop runs the risk of suffering from drought. In the very low lands, late maturing varieties (around 150 days' duration) are necessary. For other areas varieties with intermediate duration (around 120 days) would have to be chosen. There is the problem

of deep water conditions occurring due to sudden heavy downpours and floods. This problem, though typical of these parts, occurs in some areas of Bihar and Gangetic West Bengal also. For successful rice cultivation under deep water conditions, it is necessary to prevent the crop from submergence. A few varieties have been known in the past in these parts which could keep pace with the rice in the level of water, but such varieties have been very few and are low yielding. Recent experiments in Thailand and the International Rice Research Institute indicate the possibility of incorporating the gene which promotes elongation of intercalary meristem. If high yielding quality could be combined with this characteristic, it will go a long way in increasing the yields where water levels rise due to heavy rains or floods. An altogether new direction of research could be to explore the possibility of cultivation in the flood-free period in the worst affected parts of the Brahmaputra valley.

(iv) Bihar, Orissa, Uttar Pradesh, Madhya Pradesh and similar other areas (including part of West Bengal)—Waterlogging is a serious problem in these parts. Waterlogged condition hinders nitrogen uptake, retards tillering and leads to lodging in later stages. Under such a condition a variety with higher tillering ability is needed. Against lodging, there should be a plant type with intermediate stature and stiff straw. From the points of view of both tiller promotion as well as management of nitrogen, the crop in waterlogged areas can profitably be started ahead of upland areas. Then tillering is completed by the time waterlogging would become serious and nitrogen would also have been utilised by the plants in their active stage of growth prior to waterlogging. Once such a stage in plant development is completed, even a sheet of water of 30 to 60 cm depth does not seem harmful to the crop.

(v) Date of sowing and rainfall pattern—The problem is to adjust sowing time and duration for getting the maximum advantage of natural rain water and minimising dependence on irrigation water. This is a fundamental problem in all crops grown in low and high rainfall areas.

21.2.9 If action is organised on the lines indicated above, there is great scope for raising the production of rice. Even if the existing experimental claims of high yields could be partly translated in practice, there will be a radical change in farming and great prosperity.

Keeping in view the prevalent levels and what is achievable experimentally, the following yields are proposed for estimating the potential production in 2000 AD :—

States	Rice Yields (tonnes/ha)	
	Present	Proposed
Punjab, Haryana, Karnataka, Tamil Nadu	1.7—1.9	3.5
Kerala, Andhra Pradesh, West Bengal	1.3—1.5	3.2
N.E. States, Orissa, Rajasthan, Gujarat, Maharashtra	0.9—1.1	3.0
Uttar Pradesh, Bihar, Madhya Pradesh	0.8	2.8
other parts	1.1—1.8	3.0

On the basis of the proposed levels and yields per hectare, it will be possible to reduce the area under rice in order to make room for other crops. The area could be stabilized at 32 Mha with the following changes :—

(i) In Uttar Pradesh, Madhya Pradesh and Bihar considerable extent of uplands are put under rice at present. Despite best efforts, many such areas do not get the advantage of assured and easy irrigation. Such areas have to be withdrawn from this crop and put profitably under crops whose water requirement though heavy, is less than rice, e.g., maize, soyabean and blackgram. A total reduction of 3.27 Mha under rice is proposed in the three States.

(ii) There is need for readjustment of area under the monsoon crop in Orissa. A reduction of 0.22 Mha is proposed.

(iii) In West Bengal, the prevalent rainfall patterns of the SW monsoon months are A4, A2B2, A2B1C1 or B3C1. Rainfall pattern of B3C1 type is insufficient by itself for rice cultivation. The districts with this kind of distribution are Purulia and Bankura. Slightly better condition than this is provided by the rainfall pattern of the type A2B1C1, but even here, the success of rice crop would depend upon irrigation to a considerable extent. The districts having this type of distribution are Murshidabad, Birbhum, Burdwan and Nadia. Although these districts are considered to be constituting a very important rice growing area of the State, a point to be considered is whether rice cultivation could not be withdrawn in favour of less water requiring crops at least from such lands in these districts where irrigation water cannot be commanded easily. Considering these points, a cut of about a million hectares is proposed. The crops which could be tried in the lands released from rice may be the same as

suggested for Uttar Pradesh, etc.

(iv) It has been amply emphasized that even though rainfall by itself is not adequate, the States of Karnataka, Andhra Pradesh and Tamil Nadu grow rice by diverting maximum irrigation water for the use of this crop. There is need to rationalize this position, because the demand in these parts for other crops like fruits, vegetables, fibres and fodder will also increase in future. From an all-India angle, these States can contribute better by growing crops like cotton and groundnut. Maize can also be fitted in. Considering these facts, it is necessary to reduce the area under rice. The present total area under rice in these States is 6.99 Mha. It could be reduced by 1 Mha. In reduction, opportunity should be taken to adjust area under tank irrigated crop. At present, tank water is even lifted to irrigate distant rice fields. In future, rice should be permitted only to an extent to which flow irrigation can command it.

21.2.10 The position with regard to area and yield, as it would appear in 2000 AD, is presented in Table 21.3. Irrigation targets have also been allocated according to the total availability of water for rice in conformity with the views expressed in the foregoing paragraphs. Normally speaking, rainfed nature of a crop always connotes some stress of moisture conditions in the soil and, therefore, rainfed crops yield less than irrigated crops. In the case of rice, what is contemplated is that its cultivation should be so distributed that the water needs could be met in full either by the rainfall itself or through resort to irrigation or through a combination of both. In any case, the object is not to make the crop suffer from want of water as far as possible, because of which it should be possible to expect almost identical standards of yield under both the conditions. Accordingly, the yield standards as shown against different States in Table 21.3 are made applicable to the total area without distinction of irrigated or rainfed nature of the crop. For 2000 AD the following main features are to be noted :—

(i) The area under rice gets reduced by about 15 per cent and will stand at 32 Mha.

(ii) The support of supplemental irrigation, which has been provided to this crop, will cover 75 per cent of the total area as against 40 per cent as at present.

(iii) The total production will work out to be about 97 million tonnes, giving an average all-India yield of about 3 tonnes per ha.

TABLE 21.3

Targets of Area and Yield of Rice—2000 AD

area . . . Mha
production . . million tonnes
yield . . . tonnes/ha

States	Total Area		Irrigated Area		Yield	
	present	2000 AD	present	2000 AD	present	2000 AD
Punjab, Haryana	0.68	0.68	0.60	0.68	1.7	3.5
Rajasthan, Gujarat, Maharashtra, Orissa, North Eastern States	9.22	9.00(a)	2.53	5.02	1.0	3.0
Uttar Pradesh, Bihar, Madhya Pradesh	14.36	11.09	3.18	10.07	0.8	2.8
Karnataka	1.13	1.00	0.74	0.80	1.9	3.5
Andhra Pradesh	3.18	2.75	3.15	2.75	1.4	3.2
Tamil Nadu	2.68	2.25	2.41	1.70	1.9	3.5
Kerala	0.87	0.80	0.49	0.40	1.5	3.2
West Bengal	4.99	4.00	1.35	2.15	1.3	3.2
other parts	0.43	0.43	0.31	0.43	1.6	3.0
all-India	37.54	32.00	14.76	24.00	1.1	3.04

(a) reduction of 0.22 Mha refers to Orissa.

3 KHARIF CEREALS OTHER THAN RICE

21.3.1 This section relates to maize, jowar, bajra, ragi and other small millets. When a reference is made to all these crops as a group, these will be called merely as 'millets'. Small millets generally include the following :—

Botanical name	Popular name	Regional name
Eleusine coracona	finger millet	marua, nagli, ragi
Panicum milliare	little millet	samai, sawan
Panicum miliaceum	proso millet common millet broom corn millet	chena, panivaragu
Setaria	foxtail millet	kakun
Italica	Italian millet	tenai
Paspalum	kodo millet	kodon
Scrobiculatum		varagu
Echinochloa frumentacea	Barnyard-millet	sanwa

Ragi has assumed a significant place in the consumption pattern, specially in the peninsula and some hilly parts in the north and, therefore,

it will be considered as a separate crop and the phrase 'small millets' will be used to denote others of the minor types.

21.3.2 The food and fibre crops grown during kharif season depending upon the rainfall of the SW monsoon account approximately for about 57 per cent of the gross cropped area of the country as indicated below :—

Crop	Per cent of gross cropped area
rice (kharif)	18.0
millets	21.8
pulses	5.4
oilseeds	6.3
fibres	5.3
	56.8

Millets account for about 40 per cent of the above-mentioned *kharif* crops. Rice requires irrigation even during *kharif* season, but millets are predominantly rainfed. Their distribution in different categories of rainfall together with an idea of their performance is provided in summary form in Table 21.4 extracted from Appendix 21.6—Statements I to VI. But for maize, 76 per cent of the area under which falls in the higher categories of rainfall between A4 and B2 types (A2=25.4 and B2=30.9 per cent), jowar and bajra are found to be scattered within a wide range from B2 to D3. Ragi and small millets are found distributed over a still wider range from A4 to D3. The distribution of millet crops is explained later. It may, however, be noted that all these crops fit very satisfactorily within the overall cropped area, distributed in different rainfall categories. The general distribution is given below for ready reference :

Rainfall categories	Per cent of overall cropped area of the country
A4-B3	38.6
B2	14.7
B1-C3	20.1
C2	11.3
C1-D3	8.5
D2-E4	4.00
	97.2

Note : B2 and C2 are given separately, so that these could be combined upwards or downwards according to need.

In view of what has been said above, it is desirable that these crops have to be given consideration to the fullest possible extent for increasing production.

TABLE 21.4

Distribution of Area and Districts according to levels of RYI and Categories of South West Monsoon Months Rainfall—Millet Crops

	Rainfall categories				
1. *maize (present area=5.68 Mha)*	A4—B2(n)	B1—C2	CI	D2—E4	
per cent of total area	75.9	21.9	0.4	1.8	
number of districts with RYI					
below 90	62	7	..	2	125
above 90	34	19	..	1	
2. *kharif jowar (present area*=11.02 Mha)	A4—B3(n)	B2—C3	C2—D3	D2—E4	
per cent of total area	19.5	56.8	23.7	..	
number of districts with RYI					
below 90	8	38-3/4	14-1/4	..	149
above 90	26	41-1/2	20-1/2	..	
3. *bajra (present area*=12.41 *Mha)*					
per cent of total area	2.8	41.9	47.3	8.1	
number of districts with RYI					
below 90	..	18	18	4	118
above 90	8	48	19	3	
4. *ragi (present area*=2.45 *Mha)*					
per cent of total area	33.7	17.7	44.2	4.4	
number of districts with RYI					
below 90	9	6	3	..	52
above 90	12	2	17	3	
5. *small millets (present area*=4.79 *Mha)*					
per cent of total area	54.6	14.2	27.5	3.7	
number of districts with RYI					
below 90	28	13	6	..	95
above 90	28	8	9	3	

NOTES : (a) Districts with area of 10,000 ha or more have been considered.

(b) Area and RYI (Relative yield index, i.e., the local yield expressed as % of all-India) relate to the period 1969-69 to 1970-71.

(n) The most important type in this category is A2, next is A1 and much less area is either in A4/A3 or B4/B3.

21.3.3 Reverting to the distribution of millets in different rainfall categories, it can be observed from Table 21.4 that there is concentration of maize in A4 to B2, of jowar in B2 to C3 and of bajra in C2 to D3 areas. The picture, however gets diffused, because there is a gradation in the soil requirements in the order: maize, jowar, bajra and ragi or other small millets. Under higher rainfall, when once the allocation of the land to rice has been completed, the next best lands are put under maize. Once a choice has been made for maize, the next best lands are put under jowar and the next best under bajra and the

least productive lands are put under ragi or small millets. It is for this reason that jowar and bajra are found to be distributed over a wide spectrum of rainfall distribution. Insofar as ragi and small millets are concerned, these crops have two significant characteristics, viz., (a) a high degree of resistance to soil drought and (b) capability to thrive on poor and shallow soils. Because of the first and second characteristics taken together, ragi and small millets are preferred under rainfall distribution of lower amounts, say below B1. Because of the second characteristic alone, these are preferred even on the slopes of hills.

21.3.4 Millets are significant for both human consumption and multifarious uses. Many of the millet crops provide green fodder. This aspect is dealt with separately in Chapter 25 on Fodder Crops. The area provision for millets is exclusive of green fodder requirements. Dry fodder comes from the stovers. Grains are also useful for providing concentrate ration to animals and birds. Corn and millet production in the USA far exceeds that of wheat (122 million tonnes as compared with 37 million tonnes of wheat). Most of it is used for animal feeding. This will have to be the pattern of production in India for the success of livestock development. The use of coarse grains for cattle feed is dependent on favourable price; this will become possible in future when unit costs get reduced because of higher productivity. Besides human and animal consumption, millet grains are useful in industries. Of course, the maximum use has so far been made only of maize. About 4 per cent of the corn produced in India is consumed at present by the starch industry. In addition to indigenous contribution, the industry has to import varying quantities of corn from outside annually. The average import during four years ending 1969 was 31,000 tonnes. This dependence on outside sources has to cease. Sorghum can also profitably be used for starch manufacture. Starch industry yields many byproducts, e.g., dextrose and glucose syrup, germ oil, industrial solvent, gums, glutins and steep water. These are useful in textile, paper, leather, pharmaceutical, soap, baby foods, packing and confectionary industries as well as in packing products and foundries. Many of the millet grains are used in brewing. Malted grain sorghum is used for food in many parts of the world. The Kafir beer of Africa is a traditional drink of Bantu people. Modern malting techniques used in the malting of barley have been successfully applied to grain sorghums. Ragi is also progressively being used for preparing malt and brew. Brewing industry can also economically utilise bajra grain. Bajra flour can be bleached and used for preparation of bread or biscuits. By adding extra glutin, it can be used in bakery products. The germ of maize and bajra contains a high percentage of oil compared with other millets. The crude oil is used in soap manufacture and refined oil is edible. The oil

free bajra meal can serve as an ideal food for cattle and birds alike. In the absence of fats, the storage life of oil free bajra grain also increases, which is an added advantage. Owing to all these potentialities, there is a fit case to lay more and more emphasis on increasing the production of millet crops. The crops are now examined individually in the following paragraphs.

Maize

21.3.5 Statewise position of area and production of maize based on the data for 1969-70 to 1971-72 is summarised in Table 21.5. The following points are worth noting :—

(i) As pointed out earlier, the largest area under maize is in A2-B2 category of rainfall, denoting its high water requirement. As the concentration of area in A2-B2 category is in the belt comprising East Uttar Pradesh, Bihar, Madhya Pradesh and adjoining parts, these in themselves account for about 65 per cent of the maize area. The yields are, however, the lowest in this belt, say around 0.8 tonnes/ha. The grain crop is sown with the start of monsoon in July in these parts. In the seedling stage and early vegetative growth, this crop is highly susceptible to waterlogging and it so happens that the concerned months of July and August are the rainiest months in these parts. Then, the crop is sensitive to deficiency of soil moisture in later growth, specially around the reproductive phase. Such a situation occurs because of breaks in the monsoon in August or insufficient rain in September. Of the two factors, drainage of maize fields is the main problem in these parts and it calls for appropriate cultural methods, e.g., cultivating this crop on ridges. Gujarat has most of its area in A1 type of rainfall and yet its yields are about 1.4 tonnes/ha, perhaps due to better rain-water management and sloping nature of lands in which this crop is grown in parts. Irrigation is nominal in these areas.

(ii) Himachal Pradesh has more area under A2 type. Its slopes provide natural means of drainage and this may perhaps be one of the causes of high yields of the order of 1.6 tonnes/ha.

(iii) The performance of Jammu & Kashmir is around 1.4 tonnes/ha. About 40 per cent of its maize is taken in the spring season after snowmelt.

(iv) The Punjab and Haryana region also records above average

yields of about 1.5 tonnes/ha. Maize area of the region records rainfall of B2-C2 category, but the irrigated area is about 70 per cent and the crop is sown early in some parts of this region.

(v) Table 21.5 is confined to States with more than 4 per cent of all-India area and amongst them, the above average performance usually lies at about 133 per cent of all-India, which cannot be considered to be a high standard.

TABLE 21.5

Statewise Area, Production and yield of maize—1969-70 to 1971-72

	Per cent of all-India			Per cent of State area under (a)	
	area	production	yield	A2-B2	B1-C2
1	2	3	4	5	6
Uttar Pradesh . .	25.9	21.1	81.4	82.5	17.5
Bihar	16.0	11.6	72.8	100.0	..
Rajasthan . . .	13.3	12.1	90.6	80.7	19.3
Madhya Pradesh . .	10.4	8.3	80.0	94.7	5.3
	65.6	53.1			
Punjab & Haryana . .	11.5	16.2	137.1	22.8	77.2
Gujarat	4.8	6.4	133.4	98.6	1.1
Jammu & Kashmir . .	4.7	6.0	129.0	48.6	12.3
Himachal Pradesh . .	4.4	6.9	157.3	95.7	4.3
Andhra Pradesh .	4.2	4.9	117.5	22.5	76.1
	29.6	40.4			
	95.2	93.5		75.4	21.8

(a) Based on Appendix 21.6—Statement I.

21.3.6 The above analysis shows the need to rationalise and increase area under this crop. Firstly, it is required to be restricted only to A2-B2 category of rainfall in order to continue to minimise irrigation needs. Secondly, its area has to be increased in consonance with the future trends or requirements. Maize will continue to command a high position in industrial uses. Its demand from piggery and poultry will also be very great. Some types like Opaque-2 contain 100 per cent more lysine and tryptophan. The leucine and isoleucine, ratio in Opaque-2 is also very favourable Trials show that this kind of maize is approximately comparable in its protein efficiency

with milk. With such developments its use as human food is also bound to increase. According to all these considerations, the following coverage is proposed for maize :—

(i) existing A2–B2 area (approx. 75% of all-India) . .	4.30 Mha
(ii) areas where water is insufficient for rice but in excess for other crops as :	
(a) Uttar Pradesh, Madhya Pradesh and Bihar . .	3.00 Mha
(b) West Bengal	0.80 Mha
(iii) rice area in Andhra Pradesh, Tamil Nadu and Karnataka which can be put under maize	0.90 Mha
	9.00 Mha

The area mentioned above does not include the area which is put under green cobs in suburban areas for consumption as such. Such a crop is taken early with the help of irrigation and can be deemed to be on par with vegetable crops.

21.3.7 Maize has received more attention in research and development work than other millet crops. The Government of India had invited experts of the Rockefeller Foundation in the early fifties to review maize research in India. They visited various maize research centres and important maize regions of the country and submitted their report in 1954. Accordingly, a Coordinated Project on maize came into being in 1957. The *ad hoc* schemes located at various research centres were pooled into this new project. The availability of a volume of introduced breeding materials from the USA, Columbia, Mexico and several other countries through Rockefeller Foundation and those developed in India provided the much needed genetic variability. As a result, a few high yielding flint hybrids (viz., Ganga 1, Ganga 101, Ranjit and Deccan) could be released for commercial cultivation in 1961. Since then, new hybrids have continued to be released for different maize growing regions. The yielding capacity of these hybrids has been 4—6 tonnes/ha for kharif and 7-8 tonnes/ha for the winter or summer-sown crops. Although the area and yield have shown definite increasing trends over years with the advent of hybrids, yet the improvement in yield has not shown any spectacular change. The most important fact responsible for this state is that whereas more than 85 per cent of the maize area is rainfed, researches, referring to varieties or cultural practices or manurial or pest control schedules, have been mainly directed to irrigated farming. This disproportionate emphasis has to cease forthwith if a real breakthrough is to be achieved. In future, irrigation will be available only to about 20 per cent of the proposed area or 1.8 Mha and this will perforce have to be protective in nature. Some essential measures which can help in increasing

production are mentioned below :—

(i) Temperature conditions make it possible to take a rabi season maize crop in the belt comprising Orissa, Andhra Pradesh, Karnataka and Tamil Nadu (Orissa has 0.07 Mha under maize). The rainfall of SW monsoon provides some basic soil moisture and then there is some rainfall even in Oct—Jan period through the NE-monsoon. Coupled with supplemental irrigation, this can answer the water needs of the crop. Under these conditions, the clear weather prevailing in these months becomes very conducive for the growth of this crop. Experiments conducted at Hyderabad in rabi season have shown yields ranging from 6.7 to 9.8 tonnes/ha. Hence, the crop could be tried in this season in these parts.

(ii) Early varieties of Satha group of maize (maturing around 60 days) have a special importance, because these are grown more or less everywhere as a summer crop for cobs. These are also suitable in areas where early floods occur. Early maturity and heat tolerance are the main qualities of this group, but their disadvantage lies in low yielding capacity. Considerable scope exists for improving yields of such varieties. Incorporation of European maize germ plasm from higher latitudes has a great deal to offer in this connection.

(iii) The high yielding maize hybrids developed by the Coordinated Project for Maize Improvement are comparatively of late maturity. This is a handicap to some extent in general acceptance, although new short duration wheats can be taken after the hybrids. Therefore, it is desirable to concentrate attention on evolving early modern types, hybrids, composites or synthetics.

(iv) Establishment of optimum plant stand is the chief factor which influences optimum yields. Comparison of various maize varieties at different plant population levels has shown that effective plant stand of 55 to 65 thousand per hactare is necessary at harvest to realise optimum yields. Some association has been observed between tolerance to high plant population and high nitrate *reductase* activity and higher placement of the ear. Development of high population responsive maize variety in future would help raise maize production.

(v) Loss through diseases is not as much as through pests. Stem borers, *Chilo zonellus* and *Sesamia inferens* cause

widespread damage to maize plants in early stages of development. Severely affected plants produce 'dead heart' and fail to provide any economic yield. Of the stem borers *Chilo zonellus* is the most important. Some hybrids or composites have shown better resistance than most maize varieties. Therefore, it is necessary to identify better sources of resistance and to upgrade level of resistance in selected populations. Investigations on host plant resistance with regard to *sesamia inferens* have not progressed very far. This requires sustained attention.

21.3.8 Bettering the soil drainage conditions in A2 to B2 areas and concomitant cultural practices has already been emphasised. If all these measures are adopted, it should be possible to raise the overall yield standard to 2.65 tonnes per hectare, which is approximately 2½ times the present level. The overall production which can thus accrue in 2000 AD from an area of 9 million hectares will be 23.85 million tonnes.

Jowar

21.3.9 The average area, production and yield of jowar based on the data for 1969-70 to 1971-72 are 17.59 Mha, 8.52 million tonnes and 0.48 tonnes/ha respectively. The Statewise position is summarised below :

	Per cent of all-India		
	area	production	yield
Maharashtra	34.2	26.4	77
Karnataka	15.5	22.2	143
Andhra Pradesh	14.7	13.4	91
Madhya Pradesh	12.6	16.0	127
Gujarat	7.3	5.4	73
Rajasthan	6.2	4.9	78
Tamil Nadu	4.1	6.4	158
Uttar Pradesh	3.9	4.5	115

In the contiguous area comprising Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu jowar is grown in kharif as well as in rabi seasons. The overall estimates of area, production and yield for the two seasons for the above region are as

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follows :

	area (Mha)	production (million tonnes)	yield (tonnes/ha)
kharif	8.73	5.01	0.57
rabi	6.82	2.65	0.39

21.3.10 The maximum rabi crop area lies in Maharashtra, Andhra Pradesh and Karnataka and their comparative position in the two seasons is as follows :

	area (Mha)	Production (million tonnes)	yield (tonnes/ha)
Maharashtra			
kharif	2.47	1.24	0.50
rabi	3.55	1.01	0.29
Karnataka			
kharif	1.16	1.07	0.92
rabi	1.56	0.83	0.53
Andhra Pradesh			
kharif	1.25	0.62	0.50
rabi	1.35	0.53	0.39

It is clear that rabi crop in these States gives poorer yields. Maharashtra has the largest area under *rabi* crop and about 50 per cent of it is concentrated in the three districts of Sholapur, Ahmednagar and Poona.

21.3.11 Jowar and bajra are the crops which can adjust to a wide range of rainfall conditions and both are distributed from A2 to C1 types, although bajra is concentrated more in the lower types of C4/C3 to C1 and less in the higher types of rainfall distribution of the kind A2 to B4/B3. But for this broad preference for rainfall, as indicated in the beginning, their distribution in a given locality is primarily determined by the soil characteristics. As these show wide variations, the two crops have to go hand-in-hand. This leaves very little room for making adjustments in their area. Accordingly, jowar area could be stabilized at a round figure of 17 Mha. The overall yield of jowar is very poor and, therefore, there is vast scope for improvement. Even if a 2½ times increase is taken into account (i.e., 1.2 tonnes/ha), the production in 2000 AD will stand at 20.4 million tonnes. For effecting improvement in this crop, the ICAR had specially

included it in its combined programme popularly known as PIRRCOM (Project for Intensification of Regional Research on Cotton, Oilseeds and Millets initiated around 1954). Noting the significant impact of commercial hybrids on sorghum production in the USA since 1956-57, the ICAR appointed an *Ad hoc* Committee to explore the possibilities of developing commercial sorghum hybrids in India. This Committee (1961) recommended that the first commercial sorghum hybrids in India might be developed using the male sterile combine Kafir 60 as the female parent. As a result of the recommendations of this Committee, the ICAR in collaboration with the Rockefeller Foundation formulated an Accelerated Hybrid Sorghum Improvement Project in 1962 within the framework of the PIRRCOM. Efforts under this project resulted in the development of the first commercial hybrids CSH-1 and CSH-2. Karnataka did show some significant progress. However, the popularity of jowar hybrids and consequent increase in production have been restricted in pockets here and there.

21.3.12 The factors impeding progress have been many. Heavy incidence of pests, especially shoot fly, higher cost of inputs required and lower consumers acceptability and storage quality of the gain have been the main deterrents to quick adoption of jowar hybrids. Developmental programmes were initially built around a single hybrid, *viz.,* CSH 1, which is a disadvantage in itself. A few others, which could be chosen and which had some advantages over CSH 1, had difficulties in seed production. The lesser output of fodder in the hybrids released is also stated to be a serious limitation to their quick spread. Absence of hybrids suitable for rabi areas is another factor responsible for low coverage. The predominant improved rabi varieties like maldandi (M 35-1), have a high quality of grain, but are of long duration (135 days). These are tall and not highly responsive to increased fertilizer doses. The performance of such varieties of longer duration is adversely affected by moisture stress in low rainfall years. Breeding work has thus far not been in a position to put forward better alternatives. Although dry farming methods have been developed in the past the most important of which is known by the name 'Bombay Dry Farming Method', the effect of droughts could not be mitigated to any desirable extent. As it will not be possible to spare irrigation water for more than 20 per cent of the jowar area even in future, attention will have to be devoted to methods and devices which can give high yields under conditions of rainfed farming. It has been shown in some recent trials at the International Crops Research Institute for the Semi Arid Tropics situated at Hyderabad (ICRISAT) that crop taken predominantly as rainfed could give yield of about 2 to 3 tonnes per hectare with one or two sprinkler irrigations during the periods of extreme stress. With the judicious use

of rain-water collected suitably in farms in the months of July and August or of irrigation supplies from other sources, it should be possible to increase jowar yields.

21.3.13 Till the advent of the first hybrids, intensive cultivation of jowar was never given any serious consideration. Poor stands, absence of fertilization and plant protection were the rule rather than exception. The only measure advocated by the Departments of Agriculture was seed treatment with sulphur to control grain smut. Fertilizer studies and recommendations were generally limited to 10—20 kg nitrogen/ha. The position has now changed and recent work has made it possible to lay down specific beneficial schedules for time of sowing, manuring, weed control and plant protection. These are required to be put into practice. It has to be recognised that hybrids have an advantage of tolerating a pressure of plant population up to even 200,000 per hectare. This is an encouraging direction for improving the production capacity per unit area. It has already been pointed out that a variety like M 35-1, though a good yielder, is not suitable because of its longer duration. Therefore, there is need for medium duration varieties, with high response to fertilizers. Diseases generally are not as serious as pests. Shoot fly, stem borer and midge are the serious pests. The hybrids are observed to be more susceptible to shoot fly than the locals if sown out of season. However, the insect control aspect of hybrid sorghums has unfortunately been so much overemphasised that it has created a scare against them. If sowings are done early, the pest is almost absent. If sown late, seed treatment with carbonfuran etc. can control the pest effectively. The borer is rarely a serious pest on the field scale. One application of granular insecticides will effectively control the pest. This is necessary only when damage is actually visible. Regarding midge, the hybrids, being early, can escape attack and, therefore, have some advantage over locals. Thus, if sown in time, the hybrids need very little or no plant protection. Plant protection could be resorted to only if needed and not indiscriminately. This sort of approach will also help in reducing cost. In some regions, striga (a parasite) is assuming serious proportions on hybrid CSH 1. It will be necessary to combat the parasite by developing resistant hybrids or appropriate control measures. All these steps will go a long way in increasing the overall production. In so far as quality aspect is concerned there is now definite evidence that the disease *pellagra,* which occurs in endemic form among sorghum eaters, is due to the high leucine content. Proper leucine and iso-leucine balance is known to ward off this disease. Therefore, this is a desirable line of work in future breeding programmes on the nutritional side.

Bajra

21.3.14 The area, production and yield of bajra are 12.39 Mha, 6.24 million tonnes and 0.50 tonnes/ha respectively (1969-70—1971-72). Statewise position is indicated below :

	Per cent of all-India		
	area	production	yield
Rajasthan	39.4	25.9	66
Gujarat	14.4	23.1	161
Maharashtra	14.3	9.6	67
Punjab & Haryana	8.7	13.9	159
Uttar Pradesh	8.3	11.6	139
Andhra Pradesh	4.5	4.4	99
Karnataka	4.3	3.5	83
Tamil Nadu	3.8	5.2	134

Rajasthan and Gujarat account for half of the country's bajra area and production. The yield levels are low in Rajasthan and Maharashtra. In Rajasthan, about 0.8 Mha of area is in D_2E_3 type of rainfall pattern, which can hardly support any crop. We have, therefore, already stressed in our Interim Report on Desert Development the need for diverting the area to fodder grasses. However, the area thus diverted can be made good elsewhere by due adjustments so that the total area under this crop could be maintained more or less at the existing level, say 12.0 Mha, as far as yields are concerned, researches did show encouraging possibilities. The identification of cytoplasmic line with the requisite plant type by Burtun in 1958 and its dwarf counterparts subsequently permitted the exploitation of heterosis on a commercial scale. The first cytoplasmic male sterile, TIFT 23A was evolved in Tifton, Georgia, USA and this line has been most extensively used in the production of commercial hybrids in India. The first commercial grain hybrid HB-1 was released in 1965. Subsequently, some more hybrids were released between 1966 and 1968. A quick spurt was evident in the beginning in the popularity of hybrids, specially in Gujarat and Rajasthan. But it could not be maintained mainly because hybrids were noticed to be susceptible to downy mildew and ergot. In the early years of spread of these hybrids, the incidence of these diseases was sporadic and the hybrids HB_1 and HB_3 suffered only in certain regions. This, however, did not very much hamper their progress. Soon heavy incidence of the downy mildew disease was noticed in the hybrid HB_4, which had been recommended for cultivation under irrigated or high moisture conditions. Since then,

the spread of the disease was significant enough to bring down the total production. Farmers developed a sort of reluctance to accept readily the new hybrids.

21.3.15 Persistent efforts have succeeded in the rectification of the susceptible parent, TIFT 23A, and it has resulted in the isolation of a couple of male steriles, which have a high degree of resistance to mildew under artificial inoculation. Ergot is yet to be tackled successfully. However, one single quality of hybrids which has changed entirely the concept of plant type of bajra has been the habit of hybrids relating to high tillering. With judicious agronomic management high tillering has an advantage in increasing the plant population per hectare and thus contributing towards a higher yield of grain as well as fodder. If one has to sort out the best in agronomic research done so far the success of transplanting trials deserves special mention. The crop sown in August causes reduction in grain yield, but in such late conditions transplanting of seedlings before tiller initiation gives appreciably higher yield over direct sowing. This opens up new opportunity under conditions of late onset of rains. Seed can be sown in irrigated nurseries and as and when rain comes the seedlings can be planted and thus the crop can be saved from failure. A comparative study is given below of the grain yield in quintals per hectare under direct sowing and transplanting :

	July 15	July 30	August 14	August 29
direct seeding	25.92	16.61	3.72	0.35
transplanting	20.26	18.71	20.31	7.13

Direct seeding seems to be advantageous up to July 15, but transplanting can be useful up to August 15. Transplanting can help in stabilising the yield in general and at the same time cause saving in seed requirement. Another agronomic result of importance is the method of bajra being seeded in dry soil in rainfed areas. Sowing dry at a shallow depth of 1 to 1.5 cm followed by packing with a light roller is found to give good germination and stand when rains are received.

21.3.16 A difficulty with bajra is the menace caused by birds. Investment in bird-scaring is considerable. This can be avoided by the incorporation of bristles through breeding. Progress with regard to improvement of grain quality of bajra is not very satisfactory. No doubt, it has high protein content and other nutrients, but it is hard to digest. Phytic acid and other factors reducing digestibility need to be studied and countered. The fatty acid composition should also be studied in detail to determine causes that reduce the keeping quality of bajra flour. Bajra *chapatis* are coarse in texture. The factors contributing

to the coarse texture of *chapatis* require to be extensively studied. Studies on these lines can help in the development of better bajra types even from nutritional point of view. Such quality improvements are bound to increase consumer acceptance. Concerted moves to develop high yielding, disease and bird resistant varieties accompanied by due agronomic methods including dry sowing and transplanting according to situations provide ample scope to improve yields and even if a 2-1/2 times increase could be realised, the production in 2000 AD will stand at 15.0 million tonnes.

Ragi

21.3.17 The area, production and yield of ragi are respectively 2.55 Mha, 2.15 million tonnes and 0.84 tonnes/ha (1969-70—1971-72). The Stateswise position is indicated below :

	Per cent of all-India		
	area	production	yield
Karnataka	41.0	40.9	100
Tamil Nadu	12.3	15.1	123
Andhra Pradesh	11.4	11.6	101
Uttar Pradesh	10.1	10.6	105
Maharashtra	8.7	7.7	89
Bihar	6.4	3.5	55
Orissa	6.0	6.6	110

There are in all 52 districts growing ragi with area equal to 10,000 ha or more per district and 34 of them have satisfactory yields. It is mainly the crop of the peninsula, being most important in southern parts of Karnataka. Its yield surpasses that of bajra and there is a preference for this crop in dry areas. Its utility is increasing in commercial malt products. Karnataka devotes considerable attention in improving this crop, so also Tamil Nadu. Hybridisation has also been attempted in ragi primarily to combine the white grain characteristic with high yield. With the progress of such work, a few strains like Co. 8 and Co. 9 (white grained) from Tamil Nadu and Kaveri, Aruna, Purna and Hams (white grained) from Karnataka have been successfully released for cultivation. Still there is ample scope for increasing yields. With a 2-1/2 times increase over the existing average and keeping the area at 2.5 Mha as at present a production of 5.25 million tonnes can be achieved in 2000 AD. The important problems needing attention are stated below :

(i) Long duration varieties are more common in the ragi growing regions today. There is greater need now for

short duration varieties to ideally fit them into two-crop or three-crop rotation series. There is a possibility of increasing yield further by breeding for bolder grains and lesser husk. In fact, the varieties like HES-927 and HES-929 with long and compact earheads have shown growing regions today. There is greater need now for their grains are smaller in size. This defect has to be removed.

(ii) Ragi generally does not mature uniformly, due to tillers developing at different times. Hence the crop has to be harvested in two or three flushes. This is a handicap for mechanical harvesting. Breeding for uniform maturity is desirable.

(iii) Ragi is lacking in seed dormancy. There is considerable grain sprouting if rains occur and if there is delay in either harvesting the crop or drying the grain in time. None of the varieties under cultivation is free from this defect.

In developing new varieties minimising post-harvest losses has to be kept in view.

Small Millets

21.3.18 The area, production and yield of small millets are respectively 4.68 Mha, 1.77 million tonnes and 0.38 tonnes/ha (1969-70—1971-72). Statewise position is as follows :

	Per cent of all-India		
	area	production	yield
Madhya Pradesh	34.8	21.4	61
Andhra Pradesh	16.4	11.9	73
Uttar Pradesh	10.5	16.1	153
Tamil Nadu	10.2	20.5	201
Karnataka	9.0	5.3	59
Bihar	4.8	5.6	116
Maharashtra	4.5	4.6	102
Orissa	3.5	3.6	105
Gujarat	3.3	7.2	219

Though yields appear to be satisfactory in majority of cases out of a total of 95 districts growing small millets with an area of 10,000 ha or more per district, nearly half record less than 90 per cent of all-India output. Of this 26 districts are in Madhya Pradesh. In Madhya Pradesh, the maximum concentration of small millets is in A2 and A1 areas, amounting to 64 per cent of the total area of these crops under

these types of rainfall distribution. Production of small millets is less than 2 million tonnes. This is a very unsatisfactory level of production, considering that the total area under these crops is 4.7 Mha. Ragi with just about half this area, has higher production. These are poor yielding crops, but they are also neglected. Attention to these crops is mainly given in the peninsular parts. A scheme for the improvement of small millets was initiated in Tamil Nadu in 1965 with the financial aid of the ICAR. Intensive selection was made from materials collected from all over the country and outside. This work and also all other works pertaining to these crops were ultimately integrated in the All India Sorghum & Millet Coordinated Project. Under this Project, Hebbal (Karnataka) constitutes a major centre and next in order are the centres at Coimbatore, Jabalpur and Vizianagaram. Hebbal is exclusively for research on ragi.

21.3.19 Many of the minor millets are rich in minerals and some of these like Setaria (*kakun*) and Panicum (*sama*) are also known to have fat content of 4 to 5 per cent, but their digestibility is less just like bajra. These have been produced and eaten mainly in inaccessible areas or by tribals, who have cultivated them as a part of their 'shifting cultivation' methods taking advantage of their hardiness and short span of growth. With the rapid expansion of communication facilities, which is taking place nowadays, many of the farflung places will become accessible in future. 'Shifting cultivation' is also being discouraged and there is emphasis now on reclamation of the lands which have been thus exploited. Added to these factors, the inclination to utilise elite cereals will be more because of their availability in abundance resulting from increased production. Owing to all these reasons, the dependence on small millets for human consumption is not likely to increase proportionately with the rise in population, but it can be reasonably expected that the requirements would not go down below the present level of production. The grains have a utility for livestock feeding, especially birds. The existing level of production, viz., 1.50 million tonnes, could easily be attained from an area of only 2 Mha, provided the yield increases to a value of 0.75 tonnes/ha, which should not be difficult with increasing emphasis on research and better methods of cultivation. If this happens, an area of 2.7 Mha would become surplus, but it is desirable that these crops should be continued to be grown on this land and utilised for providing succulent fodder to livestock, their fodder is indeed quite satisfactory from palatability point of view.

21.3.20 In researches, the small millet crops will have to be developed separately for grain and fodder purposes. Secondly, a contrasting study of small millet crops is also called for to see if their

requirements with regard to varieties and agronomic practices etc., are different in heavy and scanty rainfall conditions. It has been observed in the beginning that small millets are grown in both these conditions. These are chosen in the former areas mostly on hill slopes, where water does not stay and the soils are very shallow. Thus, the basic similarity in both kinds of regions appears to be the less moisture availability in the soil, but the difference between the two lies in the degree of atmospheric humidity. Therefore, researches under the two conditions can be quite revealing.

4 PULSES

21.4.1 Pulses and milk are the main source of protein in a vegetarian society. In spite of possible availability of animal products rich in quality proteins in increasing quantities in future, pulses will continue to be the main source of protein to the population in the average income bracket. Moreover, pulses will play an important role in livestock feeding. The present position is that only gram is used—whole or broken—for feeding horses and ponies and draft animals and horsegram is used for feeding work animals in the south. The use of other pulses for livestock feeding has been mainly confined to their bran. This situation will change in future and the grain of many pulses will be increasingly used for this purpose. Pulses have also uses in industries. Soyabean and blackgram are used in the manufacture of protein biscuits. Canning of fresh peas as well as packing of dehydrated green peas have become popular in recent years. Clusterbean is used in the manufacture of gum, which is utilised in textile and paper industry, explosives, mining and various food products. Clusterbean seed is exported at present to the USA in small quantities of about 10,000 tonnes. Agriculturally advanced countries resort to the growing of legumes as much as possible in rotation with other crops with the twin purpose of maintaining soil fertility as well as forage production. Growing of lucerne (*alfalfa—Medicago sativa*) and berseem or other clovers (*Trifolium* or *Melilotus* or *Mdedicago sp*) is very common in the USA, Australia and New Zealand. Pea, cowpea (*Vigna sp*) and beans are some common choices in their arable crop rotations. In India, there is great potential for the utmost use of both the pulse legumes as well as forage legumes in the context of the maintenance of soil fertility. It is, therefore, necessary to see that pulses are grown substantially and due attention paid to their improvement.

21.4.2 The genera of *Leguminoseae* which provide a number of crops are *Phaseolus* and *Dolichos*. Other genera of this family also include some pulse crops. A genuswise list of some commonly known pulses is given below :

Botanical name		Popular name	Vernacular name
Genus : *Phaseolus*			
P.	*aureus*	greengram	*mung*
P.	*mungo*	blackgram	*urid*
P.	*aconitifolius*	mothbean or kidneybean	*moth*
P.	*calcaratus*	ricebean	*sutari, meth*
P.	*lunatus*	limabean	*safed sem*
P.	*vulgaris*	frenchbean	*rajma*
Genus : *Dolichos*			
D.	*biflorus*	horsegram	*kulthi*
D.	*lablab*	Indianbean or fieldbean	*sem*
Other genera			
Cajanus cajan		redgram or pigeonpea	*arhar, tur*
Cicer arietinum		gram	*chana*
Pisum sativum		fieldpea or pea	*matar*
Lens culinaris		lentil	*masur*
Lathyrus sativa		chickling vetch	*khesari*
Vicia faba		broadbean	*bakla*
Glycine max		soyabean	*bhat*
Cyamopsis tetragonoloba		clusterbean	*guar*
Vigna sinesis		cowpea	*lobia*

21.4.3 The most widely grown pulse crops in the country are gram and pigeonpea. The statistics of these two crops are published in the Estimates of Area and Production of Principal Crops in India. Other crops are mentioned in this publication as an aggregate. However, separate Statewise figures of area and production with regard to gram, pigeonpea (tur), pea, lentil (masur), *Lathyrus* (khesari), blackgram (urid), greengram (moong), horsegram (kulthi), *moth* and some miscellaneous pulses are also issued by the Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation. The second source has been used to build up comparable statistics for one year viz., 1971-72 for the individual crops. A comparison of the overall position emerging from 1971-72 data and the seven years' average for the period 1965-66 to 1971-72 derived from the first source is indicated below :

		area (Mha)	production (million tonnes)
gram	1971-72	7.91	5.08
	1965-66 to 1971-72	7.86	4.85
pigeonpea (*tur*) . .	1971-72	2.35	1.68
	1965-66 to 1971-72	2.56	1.67
other pulses . . .	1971-72	11.89	4.33
	1965-66 to 1971-72	11.80	4.24

It may be mentioned that there are two other important members of *Leguminoseae* which are also rich in proteins, viz., groundnut and soyabean but their high fat contents make them more useful as a source of edible oil. These crops have been discussed under oilseeds in Chapter 22 on Commercial Crops.

21.4.4 The all-India position as emerging from the compiled data for 1971-72 is presented in Table 21.6. Pulses occupy about 22 Mha of area and produce 11 million tonnes of grain. Kharif pulses (pigeonpea and others) contribute 41 per cent in area and 30 per cent in production, the rest being the share of rabi pulses. The area and production of gram is the highest of all the pulses, being respectively 35 and 46 per cent of total pulses. Next in importance is pigeonpea with 11 per cent of area and 15 per cent of production. The two together outweigh the rest to such an extent that in a total view on pulses as a group, these are bound to draw utmost attention. In all research and developmental programmes in India other pulses have been neglected. The most appalling picture is that of kharif pulses (other than pigeonpea) whose yield performance is the poorest, viz., only 0.25 tonnes/ha. Pests and diseases take a heavy toll of many of these pulses. Due attention should be given in all future programmes to individual pulses. Agricultural universities and State Departments of Agriculture will have to play a significant role in developing the crops of their respective regions, if a real breakthrough in production is to be attained.

TABLE 21.6

All-India Estimates of Area, Production and Yield of Pulses—1971-72

area = Mha
production = million tonnes
yield = tonnes/ha

	Area	Per cent of grand total	Production	Per cent of grand total	Yield
gram	7.91	35	5.08	46	0.64
pigeonpea (*tur*)	2.35	11	1.68	15	0.71
total	10.26	46	6.76	61	
pea	0.90	4	0.68	6	0.76
lentil (*masur*)	0.78	3	0.40	4	0.51
lathyrus (*khesari*)	1.70	8	0.89	8	0.52
other rabi pulses	1.94	9	0.71	6	0.37
total	5.32	24	2.68	24	
kharif pulses other than pigeonpea	6.57	30	1.65	15	0.25
grand total	22.15	100	11.09	100	0.50

Statewise position of individual pulses with regard to area and production has been further examined; the salient features are mentioned in the succeeding paragraphs.

Gram

21.4.5 The following tabular statement provides at a glance the distribution and performance of gram :—

	Per cent of all-India		
	area	production	yield
Uttar Pradesh	25.2	30.9	122.9
Madhya Pradesh	21.4	22.6	105.9
Rajasthan	20.7	17.3	83.6
Haryana	14.2	12.8	90.3
Maharashtra	5.4	2.6	47.0
Punjab	4.2	5.5	132.1
Bihar	3.0	3.3	110.3
West Bengal	1.6	1.8	107.8
Karnataka	1.9	1.2	62.3
Andhra Pradesh	0.9	0.4	44.5

The crop is irrigated to the extent of 20-25 per cent in Uttar Pradesh, Punjab, Haryana and Rajasthan. Gram is a low temperature loving crop and hence its distribution approximates with that of wheat. The peninsular parts record much lower yields than the north and for them separate techniques and varieties are needed. Even in the north, the returns have to be made more attractive, otherwise there is a danger that the crop may be elbowed out gradually by high yielding varieties of cereal crops. With these precautions, it is desirable to stabilize the area under this crop at 8.50 Mha.

Pigeonpea (*tur*)

21.4.6 Pigeonpea is cultivated in almost all the parts, but the main concentration is in Madhya Pradesh, Maharashtra and Uttar

Pradesh. Statewise position is as under :—

	Per cent of all-India		
	area	production	yield
Madhya Pradesh	21.4	25.6	119.8
Maharashtra	20.5	14.9	72.6
Uttar Pradesh	20.1	35.7	177.9
Karnataka	13.2	9.5	71.9
Andhra Pradesh	8.1	2.4	29.4
Bihar	3.9	3.6	92.9
Gujarat	3.9	3.0	77.3
Tamil Nadu	4.3	2.4	55 7
Orissa	2.1	1.2	55.7
Rajasthan	1.3	1.2	92.9

The yields over the peninsula are lower than the north. Madhya Pradesh and Uttar Pradesh give better yields than other parts. The main handicaps with the crop are two, viz., its long duration covering the kharif as well as rabi seasons and susceptibility to frost in the northern parts. Frost resistance has defied solution all through and, therefore, it will be safer to give increased attention to this crop in frost-free areas. However, it faces competition with a better paying crop like cotton in the peninsula and, therefore, the main strategy will be only to improve yields and shorten the duration. In fact, medium duration single-season varieties are the key to popularise this crop universally. In the north, such varieties have the advantage of escaping frost. It should also be possible to effect increases in area anywhere outside the peninsula. Until medium duration varieties become available, the main area for expansion will have to be in the States of Madhya Pradesh, Bihar, Orissa and West Bengal. An area of 3 Mha representing a small increase of 0.65 Mha over the existing area should be earmarked for this crop.

Kharif Pulses other than pigeonpea—

Blackgram (*urid*), greengram (*mung*), horsegram (*kulthi*) and *moth*

21.4.7 These crops account for 90.6 per cent of the area under kharif pulses other than pigeonpea, their individual share being 21.4,

22.4, 20.1 and 26.6 per cent respectively. Their distribution in different States is indicated below :

	Per cent of all-India area of the concerned pulses			
	black-gram	green-gram	horse-gram	*moth*
Madhya Pradesh	34.2	12.3	14.6	..
Maharashtra	20.8	19.3	15.9	6.5
Uttar Pradesh	10.3	..	..	..
Tamil Nadu	6.9	5.4	14.8	..
Bihar	6.6	..	9.5	..
Karnataka	4.1	5.5	33.1	..
Rajasthan	3.8	19.1	..	89.1
Andhra Pradesh	3.8	26.0	10.5	..
Gujarat	..	6.8	..	..
others	9.5	5.6	1.6	4.4

On the basis of the district data available in the Season and Crop Reports and the returns furnished by the States, the distribution in different rainfall categories is indicated below:

	Per cent area of the concerned pulse			
	blackgram	greengram	horsegram	*moth*
A2–A1	34	15	23	2
B2–C4/C3	54	60	28	7
C2–D4/D3	6	23	42	49
D2 or less	3	1	5	42

A gradation of these pulses with regard to water requirement is clearly noticeable in the descending order of blackgram, greengram, horsegram and *moth*. There is an overlapping of the first three pulses with regard to rainfall zones, but the gradation is even then clearly discernible. In A2—A1 areas, blackgram is perhaps given preference on heavier soils with better moisture retention, whereas lighter soils with less moisture retentivity are assigned to greengram and horsegram. Similarly, in areas having a rainfall distribution of C2 or less, greengram is given better situations than horsegram or *moth* and with rainfall decreasing to D2 or less, the choice gets restricted to *moth*, which is the hardiest of all these pulses. These pulses and many others like cowpea, frenchbean, fieldbean (*Dolichos lablab*) should be encouraged as much as possible in order to meet different conditions of rainfall and soil during *kharif* season. Many of these crops are capable of finishing their life cycle within 60—90 days and are, therefore, suitable for multiple cropping. These are suitable even for being grown as catch crops

within the summer gap of April-June whenever water could be made available to a reasonable degree of sustenance. The hardier amongst them can easily grow on the receding riverbeds and tankbeds in this period. The growth of legumes on tankbeds can enrich the soil for maintaining aquatic vegetation in the rainy season. This can prove increasingly useful for fish rearing. The area under these pulses could be raised to 8.00 Mha from the present level of 6.57 Mha.

Rabi Pulses other than Gram

21.4.8 Table 21.6 would indicate that pea, lentil (*masur*) and Lathyrus (*khesari*) occupy 3.38 Mha whereas other miscellaneous rabi pulses occupy 1.94 Mha. The miscellaneous ones belong to the same species as many of the kharif pulses. The distribution of the first three is as follows :

	Per cent of total area of the concerned pulse		
	pea	lentil	lathyrus
Uttar Pradesh	80	23	..
Madhya Pradesh	9	34	44
Bihar	4	20	39
West Bengal	0.6	14	11

Peas are mostly concentrated in Uttar Pradesh, whereas the other two crops are mainly confined to Madhya Pradesh, Bihar and West Bengal. Pea in east Uttar Pradesh and the other two crops are usually taken in paddy fields after its harvest. *Lathyrus* is sown even while paddy to be harvested is still in field. *Lathyrus* is known to contain the free amino-acid toxin BOAA, which causes 'lathyrism'. However, the toxin being soluble is easily removable by soaking in water. Moreover, there is a variety, lakhori, which is harmless and it may be possible to breed more and more of such varieties.[1,2] It is not absolutely essential to replace this crop, specially when (a) the people accustomed to it do not wish to give it up and (b) it does have some advantage to thrive on the residual moisture of paddy fields. Even if a necessity arises to do away with its cultivation in parts, the area so released can be put under other suitable rabi pulses. Thus, the total area under these pulses could be stabilised at 5.50 Mha, which is almost the same as at present.

1 1970. ICAR, *Pulse Crops of India*, pp. 314-316.
2 1971. IARI, *New Vistas in Pulse Production*, pp. 20-22.

21.4.9 There is an official ban on the sale of Lathyrus and its products vide Prevention of Food Adulteration Rules, Ministry of Health and Family Planning, Government of India, 1955 (amended upto 1959).[1] Despite this ban, the popularity and sale of this pulse has not decreased. The picture with regard to this grain crop is not very alarming provided the people are educated in making the right use of the pulse after removing the toxin through steeping. It is said that farmers in Madhya Pradesh, who actually grow this crop, use it in this manner invariably and, therefore, lathyrism is not as much common in areas of its very cultivation as in the adjoining areas, where it is purchased and consumed. In the latter areas, it is said to be consumed in the form of *chapati* or *dal* without pre-treatment. Therefore, action is really required to be taken by the Extension or Revenue authorities to popularise the right methods of cooking in all the concerned areas.

21.4.10 It has already been stated that research and developmental activities with regard to pulses in general have not received due attention. The crops which have received most attention, viz., pigeonpea and gram, are also posing difficult problems. Unduly long duration of pigeonpea and its susceptibility to frost have been pointed out earlier. The problem of wilt disease has also not been fully solved. Varieties with compact canopy which enable higher plant population, are also not abundant. In respect of gram, there has been as yet no striking change in the varietal/picture and the established varieties continue to be popular. The All India Coordinated Project on Pulse Crops also came a little late, i.e., during the Fourth Plan; its impact has not been felt thus far. However, it does not mean that beneficial results are not at all available. There was a time when it was thought that manuring of legumes was superfluous, but it is more or less established now that phosphatic fertilisers lead to improvement in yield. There is considerable evidence to show that addition of a small starter dose of nitrogen can have stimulating effect on nodulation and consequently on symbiotic fixation. Field inoculation with *Rhizobium* can bring about 50—100 per cent increase in grain yield. It has also been found that pelleting of the inoculated seed with $CaCo_3$ or $CaSo_4$ in highly acidic or alkaline soils can help to get the *Rhizobium* established, resulting in better crops. Attempts are continuously being made to identify efficient strains indigenous to the soil of different parts of the country for each of the pulse crops. Ridge cultivation of pulses prone to waterlogging in kharif season gives better aeration, which is quite essential for the optimum functioning of the root bacteria. Experiments have shown that ridge planting leads

1. 1962 CSIR, The Wealth of India Raw Materials, Vol. VI (L-M), pp. 40-41.

to a 30 per cent increase in yield over planting in flat beds in the case of pigeonpea and to nearly 50 per cent in the case of blackgram and greengram. Weed Control has proved to be very valuable in the case of pulse crops, because weeds generally swamp their fields owing to the inherent slow seedling growth of legumes.

21.4.11 While some useful results are available, their effect is not apparent in the field. The growth of pulses is taken for granted and farmers do not give specific attention to their cultivation. There is no proper care after the seed has been sown. Farmers take advantage of the dual utility of many of these crops. If fruiting is found to be satisfactory, the crop is harvested for grains. Otherwise, it is diverted for the purpose of fodder. The yields are naturally low with such an attitude. It is clear that extension activities have failed to make their impact and, therefore, the first immediate need in these crops is to make available to farmers the existing know-how and associated inputs. The second important need is to give up all-India coordination of the type that exists today even in research work. There is a distinct yield gap between the peninsular States and the rest of the country in the case of both the important crops, viz., pigeonpea and gram. Crops species also differ between the peninsula and elsewhere. Horsegram and *Dolichos lablab* are very typical of the drier parts of the south. The species of pulses which are common in the hills of West Uttar Pradesh and Himachal Pradesh are different from those of the plains. In the drier parts of Rajasthan, the emphasis is on *moth* and *guar* (clusterbean). For these reasons, decentralisation of research efforts is absolutely essential and, as already suggested, every agricultural university must be able to take initiative in regard to problems typical in its jurisdiction. Broadly speaking, there should be different strategies for the peninsula, the northern plains, hills and eastern parts and to this extent regional coordination could be permissible.

21.4.12 Some recent tests have shown the possibility of attaining 4-5 tonnes/ha yields in pigeonpea, 3-3.5 tonnes/ha in gram and peas and 2-2.5 tonnes/ha in black and greengram. It is observed that one irrigation for gram before flowering stage is the minimum essential requirement in case the winter precipitation does not occur in time. This equally holds good for peas. In order to cover such needs and provide protective irrigation under critical circumstances even in kharif season, a provision has been made for irrigation to the extent of 5.37 Mha. This works out to be approximately 20 per cent of the total proposed pulse area for the country. With the water need of these crops fully satisfied by rain or irrigation water, utilising better varieties and modern methods of cultivation and giving due importance to all possible pulse crops, it should be possible to attain an yield level

of at least 1.5 tonnes/ha in general. It would mean 2½ times increase in the case of gram, pea and pigeonpea, 3 times for lentil and *lathyrus* and 4—6 times for others, mostly the kharif species. It may be re-emphasised that the last group has to be given the best of attention. Most of the pulses will continue to be grown rainfed. Therefore, rainfed techniques have to be given utmost prominence in research as well as developmental activities. With these efforts alone a production of 37.5 million tonnes can be achieved.

5 GENERAL

21.5.1 In the foregoing paragraphs, we have indicated broadly the extent of area that could be put under different foodgrains in 2000 AD and its distribution over various parts of the country purely on scientific considerations with a view to maximising production. An attempt has also been made to indicate technological possibilities of increasing the yield levels of different crops on the assumption that the crops would be grown in appropriate places, at appropriate times and with the required backing of irrigation, seed, fertilisers and manures, plant protection chemicals, etc. It has further been assumed that these crops will be grown on lands with proper tilth and inter-culture status of the soil made possible by the use of ideal implements and tools. All these factors are so crucial to the attainment of the yield and production levels indicated in this chapter that any deviation from the cropping patterns envisaged by us or in the levels of inputs and extension needed for realisation of the production potential would result in lowering of the targetted levels. The estimates of area and yield of various crops envisaged for 2000 AD are presented in Table 21.7.
It will be seen that the total area under foodgrains is projected to be at the same level as in the triennium ending 1971-72, although compared to 1973-74 this shows a marginal decline. On the basis of the yield levels of various crops indicated in the foregoing sections, the production potential of foodgrains in 2000 AD is estimated at 277.16 million tonnes against the base level production of 103.78 million tonnes. Programmes for agricultural development have been outlined in different subject-matter chapters of this Report. In Chapter 11 on Supply Possibilities we have tried to assess the possible levels of various programmes and inputs like irrigation, command area development, dry land farming, high yielding varieties and fertilisers that could be attained by 2000 AD. In many areas, the levels of various inputs may fall short of the optimum requirements envisaged

TABLE 21.7

Area and Yield Targets of Foodgrain Crops as proposed for 2000 AD

	Area Mha		Yield tonnes/ha		Reference		
	present	2000 AD	present	2000 AD	table	appendix	para-graph
wheat	18.01	17.55	1.30	3.64	21.2	21.3-II	..
barley	2.58	5.50	1.03	1.97	..	21.3-VI	21.1.9
oat	..	0.50	..	4.00	..	..	21.1.12
rice	37.54	32.00	1.11	3.04	21.3	21.5-III	..
maize	5.78	9.00	1.05	2.65	21.5	..	21.3.6 21.3.8
jowar	17.59	17.00	0.49	1.20	..	..	21.3.9 21.3.11
bajra	12.39	12.00	0.50	1.25	..	..	21.3.14 21.3.16
ragi	2.55	2.50	0.84	2.10	..	..	21.3.17
small millets	4.68	2.00	0.38	0.75	..	..	21.3.18 21.3.17
gram	7.91	8.50	0.64	1.50	21.6	..	21.4.5 21.4.12
pigeonpea	2.35	3.00	0.71	1.50	21.6	..	21.4.12
pea	0.90	1.00	0.76	1.50	21.6	..	21.4.12
lentil	0.78	0.80	0.51	1.50	21.6	..	21.4.12
lathyrus	1.70	1.70	0.52	1.50	21.6	..	21.4.12
other *rabi* pulses	1.94	2.00	0.37	1.50	21.6	..	21.4.12
other *kharif* pulses	6.57	8.00	0.25	1.50	21.6	..	..
total area	123.27	123.05					

in this chapter. The motivation of farmers especially in some areas of Madhya Pradesh, eastern Uttar Pradesh, Bihar and Orissa may not be developed to the extent necessary. Further, it may not also be possible to organise services of the requisite quality to the extent needed to enable the adoption of management practices required for attaining the envisaged yield levels for various crops. It may also not be feasible to restrict the cultivation of various crops to the areas most suited for them from the agro-climatic point of view. Taking all these factors in view, the level of foodgrains production that can possibly be achieved in 2000 AD may be lower. While reviewing the supply-demand balances in Chapter 11 on Supply Possibilities, the figure of 230 million tonnes has been used. In case the country's economy develops at a faster rate than has been envisaged in this Report and it becomes possible to mobilise larger resources for agriculture, it is certainly within the realm of possibility to attain a somewhat higher level of foodgrains production by 2000 AD which may lie between 230 and 277 million tonnes.

6 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

21.6.1 The targets of area and yield for the various grain crops as contemplated for 2000 AD are given in Table 21.7. The present position has also been indicated for comparison. The salient aspects of suggested changes in cropped areas are stated below :

1. Significant increase has been suggested in barley area. About 0.34 Mha are for cultivation on saline and alkaline lands, 0.46 Mha to be transferred from wheat area and the remaining excess over the present acreage is mainly to come from rabi fallows in Uttar Pradesh, Bihar, Punjab and Haryana.

(Paragraph 21.1.9)

2. Major reduction of paddy area has been suggested in Uttar Pradesh, Madhya Pradesh and Bihar (3.27 Mha), West Bengal (0.99 Mha) and Andhra Pradesh, Tamil Nadu and Karnataka (1.00 Mha). Preference should be given to crops like cotton, groundnut and maize in the surplus areas of the south and maize, soyabean and blackgram etc. in the other States. In rice, area should be withdrawn from uplands or other unfavourable situations where irrigation water cannot be provided easily to supplement rain-water. Wherever tank irrigation is prevalent, as in the south, rice should be confined to the areas where water can reach through flow irrigation; lift irrigation should be avoided as far as possible.

(Paragraph 21.2.9)

3. Additional area of 4.7 Mha has to be brought under maize mainly from the surplus rice areas of Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal (3.8 Mha) and Andhra Pradesh, Karnataka and Tamil Nadu (0.9 Mha). A rabi crop of maize should be encouraged in Orissa, Andhra Pradesh, Karnataka and Tamil Nadu.

(Paragraphs 21.3.6 & 21.3.7)

4. Out of the total existing area of 4.7 Mha under small millets, 2.7 Mha are proposed to be diverted to fodder raising and only 2 Mha are to be retained for grain production.

(Paragraph 21.3.19)

5. For pigeonpea, until medium duration varieties become available, the main thrust of area expansion will have to be in frost-free areas of the north, because the peninsula does not hold promise in this regard owing to competition from crops like cotton.

(Paragraph 21.4.6)

6. For increasing area under miscellaneous pulses, due consideration should be given to multiple cropping. Offseason cropping in April to June period in riverbeds and tankbeds should also be given a trial wherever feasible.

(Paragraph 21.4.7)

21.6.2 Emphasis in researches has usually been on improving yield by quantity rather than quality except for cotton, and agronomic aspects have not received due attention. Specific recommendations are indicated below :—

1. There is need to make a realistic distinction in crop research relating to irrigated and rainfed conditions proportionate to the area obtainable under each condition. For example, a crop like maize requires emphasis on rainfed conditions, whereas the emphasis has usually been for irrigated conditions. For wheat, the efforts are also required to be directed towards successful rainfed crop raising, whereas the attention has been mostly given to irrigated crop so far. Crops like barley, jower and pulses also require attention in research for rainfed conditions.

(Paragraphs 21.1.4, 21.1.10, 21.3.7, 21.3.12 & 21.4.12)

Wheat

2. Whereas the existing tempo has to be maintained in all-round research, a special programme of evolving varieties and agronomic techniques suited to warmer winter conditions of the peninsula should be put into operation.

(Paragraph 21.1.4)

3. Due attention should be paid in research work to durum and

dicoccum species, which hold better promise for the south. Special varieties of wheat are required to be bred and cultivated for milling, baking and confectionary industries also.

(Paragraph 21.1.7)

4. The rust problem and the problem of storage pests should also get the best possible attention. In order to minimise rust menace, it is worthwhile to eliminate wheat cultivation in the high hills or to saturate their area with resistant varieties. If wheat is continued to be grown in these areas, only rust-resistant varieties should be permitted. As all varieties may develop susceptibility with the passage of time, a surveillance service for rust detection on cultivated wheats will have to be organised.

[Paragraphs 21.1.5 & 21.1.6 (iii)]

5. Extension workers have to see that the capacity of the new dwarf varieties to adjust to late sowings is not stretched too far to the detriment of yield performance.

[Paragraph 21.1.6 (i)]

6. Breeders have to provide ample choice with maximum possible diversification of genotypes in the case of wheat in order to avoid disadvantages of a narrow genetic base throughout the length and breadth of the country and extension workers have to ensure that only a couple of varieties do not catch the fancy of the farmers.

[Paragraph 21.1.6 (ii)]

Barley

7. Research work on cultivation of barley under saline and alkaline conditions should receive attention. Many pests and diseases (e.g., corn leaf aphid and molya disease) and problems like lodging have to be tackled. The nutritional quality and digestibility of grain should be improved. Varieties like Hiproly are worth developing. Attempts to increase total lipids are also necessary. Hulled barleys cause digestive difficulty and hull-less types are at present low yielding. Attempts are necessary to remove this drawback and also to breed verieties with less percentage of crude fibre, because crude fibre also impairs digestibility.

(Paragraph 21.1.10)

Oat

8. As this crop is only of local importance from cultivation point of view, its research aspects need be looked after only by the Central institutes and the agricultural universities, which are situated in the main wheat growing belt. Prevention of lodging, response to

fertilisers and improvement in nutritional quality and digestibility of grain are some of the problems which should engage attention.

(Paragraph 21.1.13)

Rice

9. The area and production of rice crops should be reported in official statistics with reference to the dates of sowing. An experimental project is necessary to determine the most feasible arrangement.

(Paragraph 21.2.3)

10. The non-consumer areas like Punjab, Haryana, Rajasthan and West Uttar Pradesh hills and adjoining parts should be encouraged to grow high quality rice for exports. But due to the heavy pressure on irrigation resources for growing rice with inadequate rainfall, attempt should be made as far as possible to confine paddy cultivation to low lying areas or those lands which suffer from salinity and alkalinity.

[Paragraph 21.2.3 (iii)]

11. Excessive rainfall should be suitably stored and used during the spells of drought as well as in the month of September when the rainfall is much less. Attempt should be made to transplant the crop in June with the backing of irrigation water to facilitate completion of its vegetative phase by the end of August. Under this arrangement it would not be subject to want of rainfall in the month of September.

[Paragraph 21.2.3 (iv)]

12. The summer sown crop (April $\pm$ 15 days) in Orissa should be given up and whatever little irrigation water is used at present for its raising in the months of April and May could be utilised for raising nurseries for monsoon crop. The monsoon crop receiving a start in June would get the full advantage of the monsoon rainfall of July and August for its vegetative growth.

[Paragraph 21.2.3 (viii)]

13. Varieties for the summer sown crop (February-May) have to be of early duration, say within 90 days, so that these could finish their life cycle before the onset of SW monsoon. Those for the monsoon crop could have a duration of 90—120 days and October-January sown crop could be even 150—160 days' long. Breeders should provide the information regarding the correct yield potential of the varieties, when they release the varieties.

[Paragraphs 21.2.3 (iv), 21.2.3 (ix) & 21.2.5]

14. Serious endeavours are required to be made to lay emphasis on the cultivation of rice in Assam and adjoining parts in the flood-free period of October onwards. This poses a connected engineering problem of harnessing rain water of the monsoon season in such a

manner that it would be available for irrigation purpose in later months.
[Paragraph 21.2.3 (ix)]

15. If irrigation could be assured in the clear season in Assam, West Bengal and Orissa, the area under different rice crops could be readjusted in the following manner giving more weightage to the October-January sown crop than at present :

	area per cent		
	Feb—May	June—Sept	Oct—Jan
North Eastern States	20	60	20
West Bengal	10	80	10
Orissa	5	80	15

[Paragraph 21.2.3 (ix)]

16. Considering the peculiarities of this crop, rice research could be regionalised in the following manner : (a) Jammu & Kashmir, Himachal Pradesh and West Uttar Pradesh hills, (b) Punjab, Haryana, Delhi and Rajasthan, (c) Gujarat and Maharashtra, (d) Uttar Pradesh, Madhya Pradesh and Bihar, (e) West Bengal and Orissa, (f) North-Eastern States, (g) Karnataka, Andhra Pradesh and Tamil Nadu and (h) Kerala, coastal Karnataka and coastal Maharashtra. Each region should be independent and self-sufficient by itself in research as well as extension efforts. Each region should have its own research institute of all-India status. The overall all-India problems could be looked after by the CRRI in collaboration with these institutes. On extension side, the Ministry of Agriculture and Irrigation can develop suitable regional machinery with the involvement of the State Department of Agriculture.

(Paragraph 21.2.8)

17. The main research problems which call for special attention in the case of rice are (a) to fit the varieties as well as agronomic practices to local rainfall rhythm of different parts, (b) water and soil management under excess as well as deficient rainfall conditions and (c) finding suitable varieties for different situations (hills, valleys and plains etc.) and for different crop seasons.

(Paragraph 21.2.8)

18. It is desirable to improve drainage of maize fields through cultural practices in order to avoid damage due to waterlogging.

(Paragraph 21.3.5)

19. The existing drawback in maize is that the early varieties are low yielders and the high yielding hybrids are too late for the rabi crops to be sown in time. This drawback is to be removed through persistent breeding efforts. Response to high population stress and

resistance to borers are the other characteristics which have to be kept in view in breeding work.

[Paragraph 21.3.7 (ii)-(iii)]

Jowar

20. Breeding efforts should attempt to introduce a proper leucine and isoleucine balance in jowar grains in order to ward off Pellagra disease. It is also necessary to breed medium duration fertilizer responsive rabi jowar. Striga the plant parasite also needs attention either through developing resistant hybrid or through proper control measures. Extension efforts are required to ensure that beneficial practices relating to time of sowing, manuring, optimum plant population, weed control and plant protection are adopted by farmers on a large scale.

(Paragraph 21.3.13)

Bajra

21. The need is to develop high yielding, disease and bird resistant varieties alongside due agronomic methods including dry sowing and transplanting for different circumstances. Digestibility and keeping quality of flour are the other factors which require attention.

(Paragraph 21.3.16)

Ragi

22. Breeding for short duration, bold grain with less husk and uniform maturity is desirable. Introduction of dormancy is necessary.

(Paragraph 21.3.17)

Small millets

23. Fodder and grain aspects have to be separated in research work. A contrasting study is also needed for the small millets which are grown in apparently two dissimilar conditions, viz., high and low rainfall areas.

(Paragraph 21.3.20)

Gram

24. Improvement of yield in gram can be achieved by breeding significantly better varieties of this crop and provision of at least one

irrigation between sowing time and flowering date according to exigencies.

(Paragraphs 21.4.6, 21.4.12)

Pigeonpea (*arhar or tur*)

25. In the case of pigeonpea, attempts have to be continued to seed for medium duration single-season high yielding varieties suitable for different parts and for frost as well as wilt resistance.

(Paragraphs 21.4.6, 21.4.10)

Lathyrus (*Khesari*)

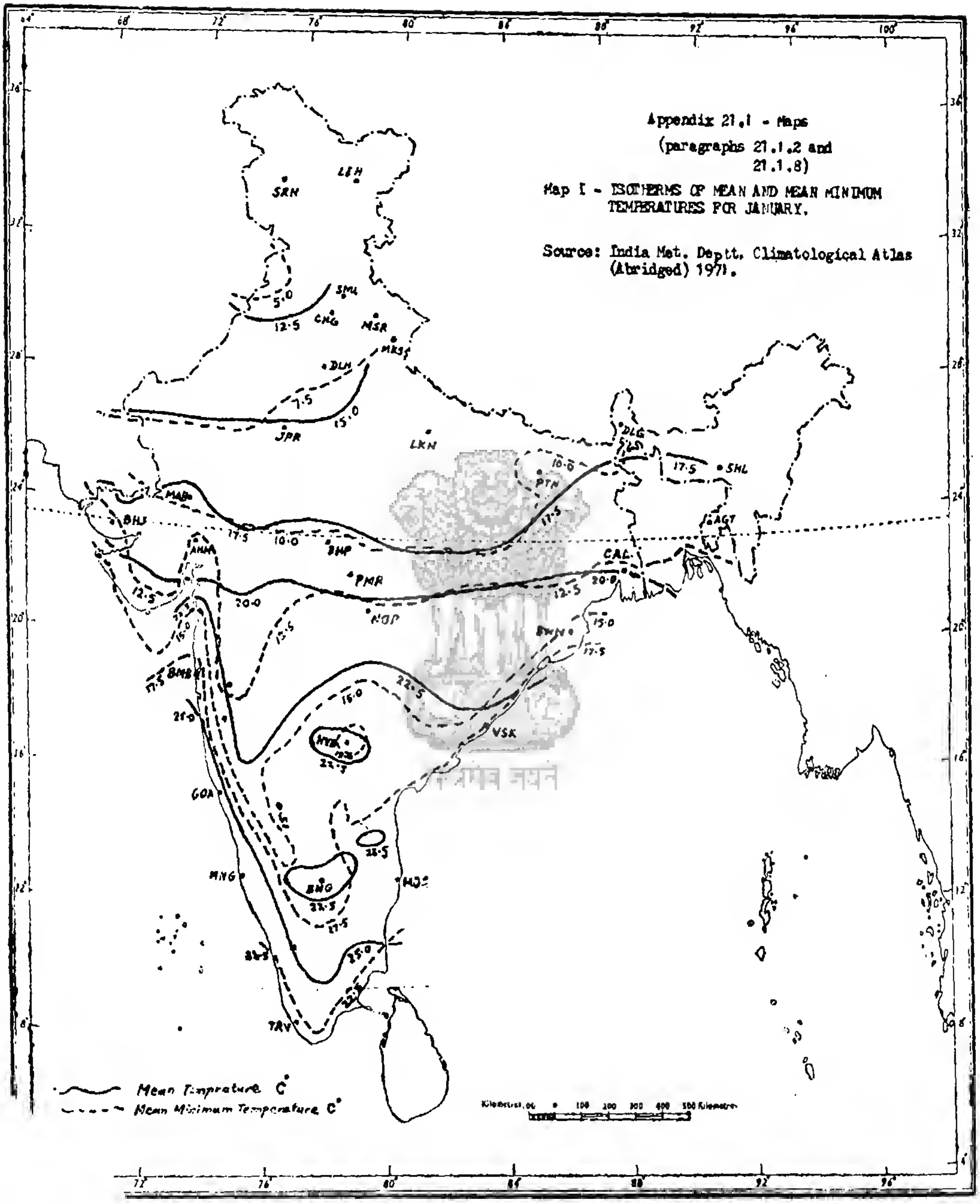
26. The main problem in the case of this crop is to educate people in the proper use of the pulse and here the help of extension and revenue authorities could prove quite beneficial.

(Paragraph 21.4.9)

Other pulses

27. Due attention is required to be given to blackgram, greengram, horsegram, *moth* and many others like cowpea, frenchbean, *Dolichos lablab* in order that different conditions of rainfall and soil could be met successfully in different parts. The agricultural universities and State Departments of Agriculture will have to draw up their own strategies concerning typical problems in regard to the pulses of their regions. Co-ordination could be broadly arranged for the peninsula, northern plains, hills and eastern parts. The extension machinery should be made to give top priority to make available to farmers the existing knowhow and associated inputs.

(Paragraphs 21.4.4, 21.4.7, 21.4.11)

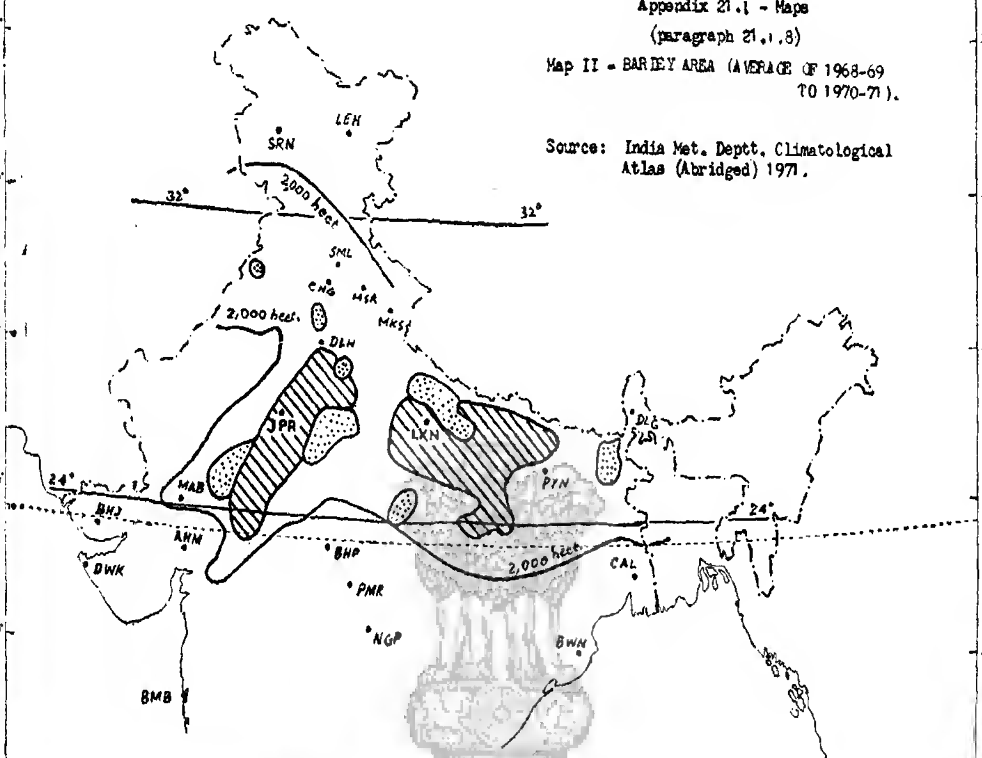


... extend into the sea to a distance of twelve nautical miles
· base line

Appendix 21.1 - Maps
(paragraph 21.1.8)

Map II - BARLEY AREA (AVERAGE OF 1968-69 TO 1970-71).

Source: India Met. Deptt. Climatological Atlas (Abridged) 1971.



Number of districts in various ranges of area

ranges of area (hect)		no. of districts
2,000 - 10,000	...	50
10,000 - 20,000	...	25
20,000 - 40,000	...	13
≥40,000	...	26

Names of districts having area 40,000 hectares or more

RAJASTHAN	UTTAR PRADESH		BIHAR
Udaipur	Aligarh	Jaunpur	Muzaffarpur
Bhilwara	Kanpur	Pratapgarh	Saran
Tonk	Unnao	Gazipur	Champaran
Jaipur	Rai Bareilly	Azamgarh	MADHYA PRADESH
Alwar	Fatehpur	Basti	Sidhi
~~HARYANA~~	~~ALLAHABAD~~	Gorakhpur	
Gurgaon	Mirzapur	Deoria	
	Varanasi	Ballia	

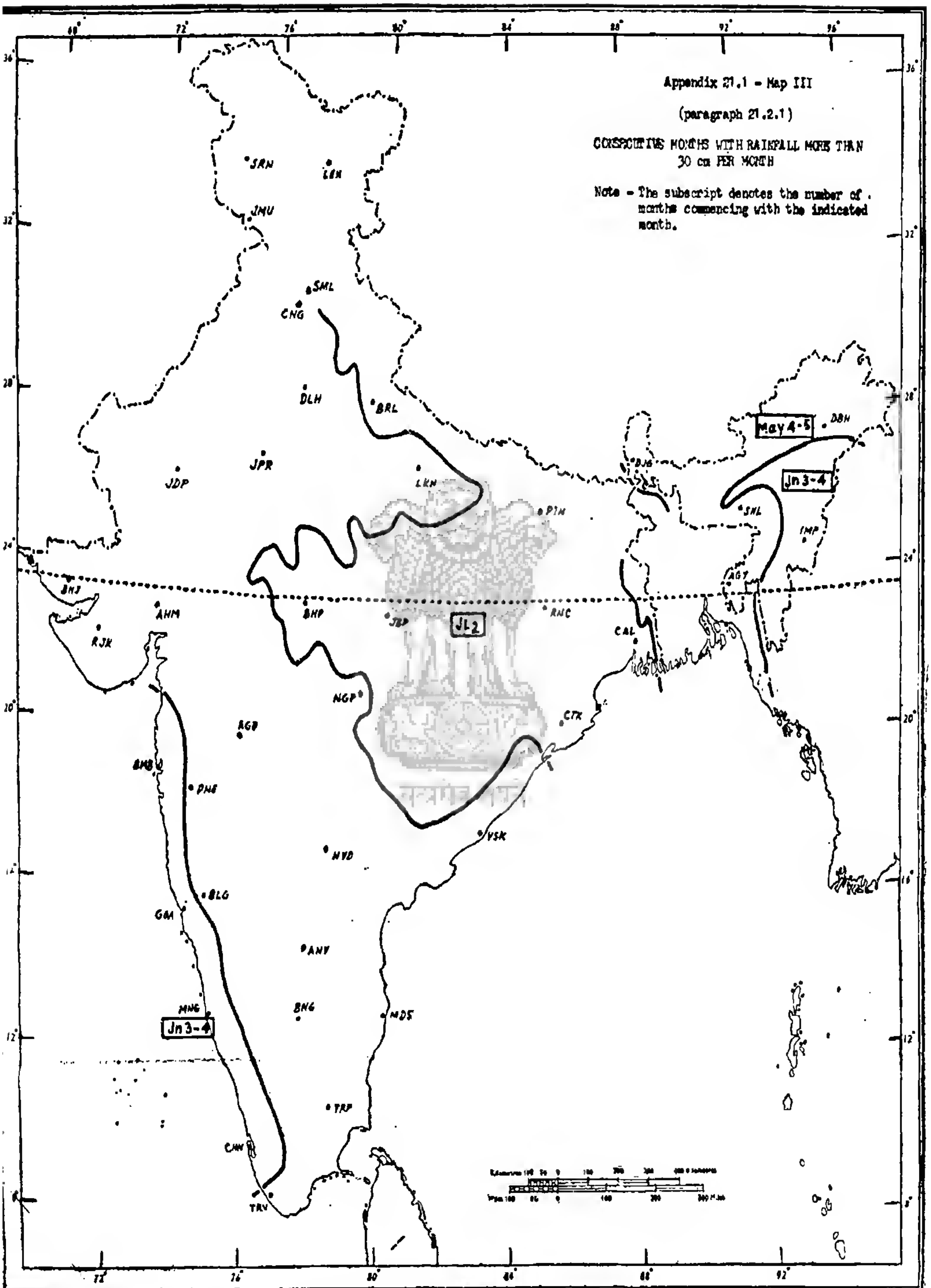
AREA > 20,000 Hectare per district.

Kilometers 100 0 100 200 300 400 500 Kilometers

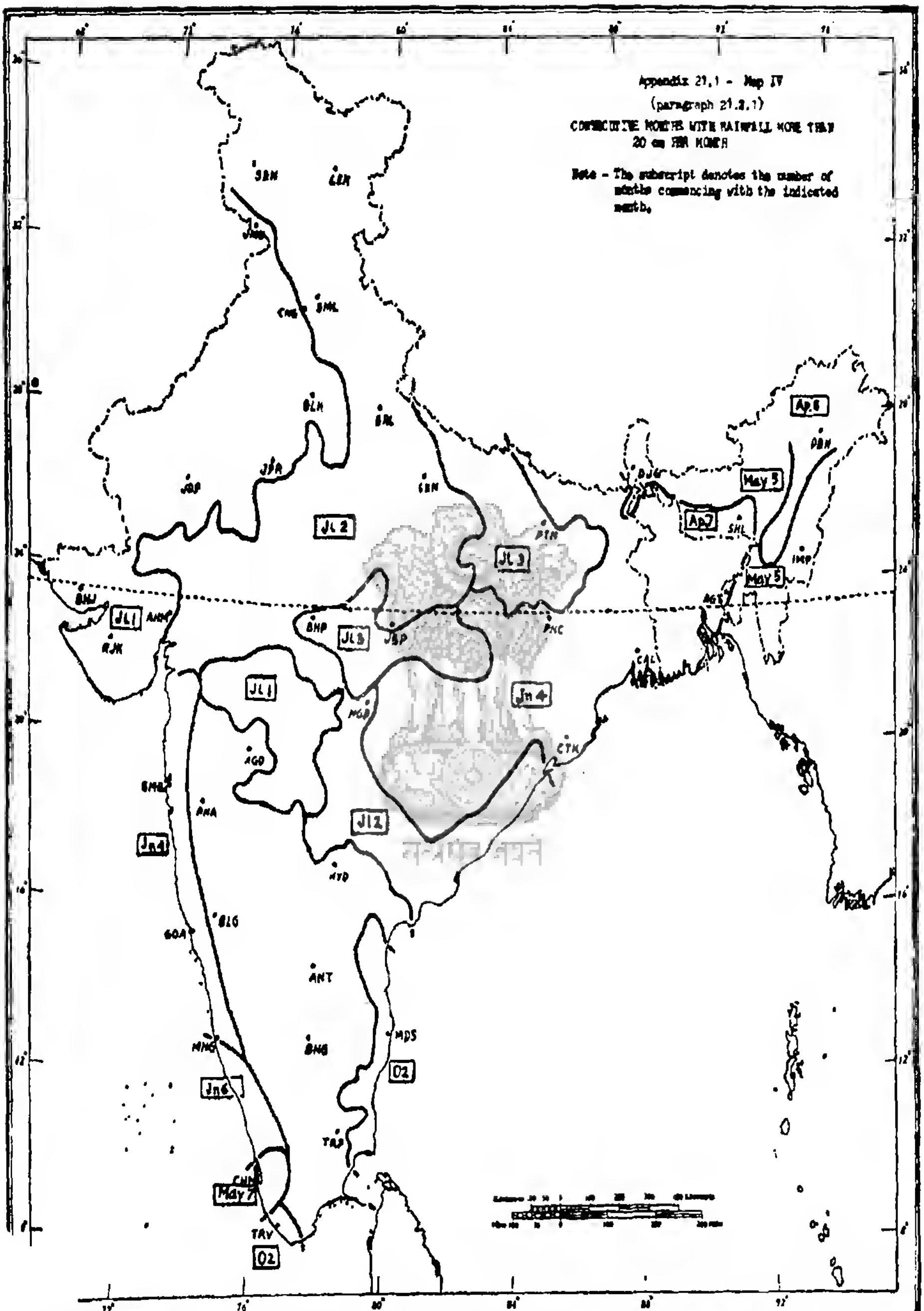
AREA > 40,000 Hectare per district.

Area more than 2000 hectare per district shown within the outer lines; *hect = Hectare*

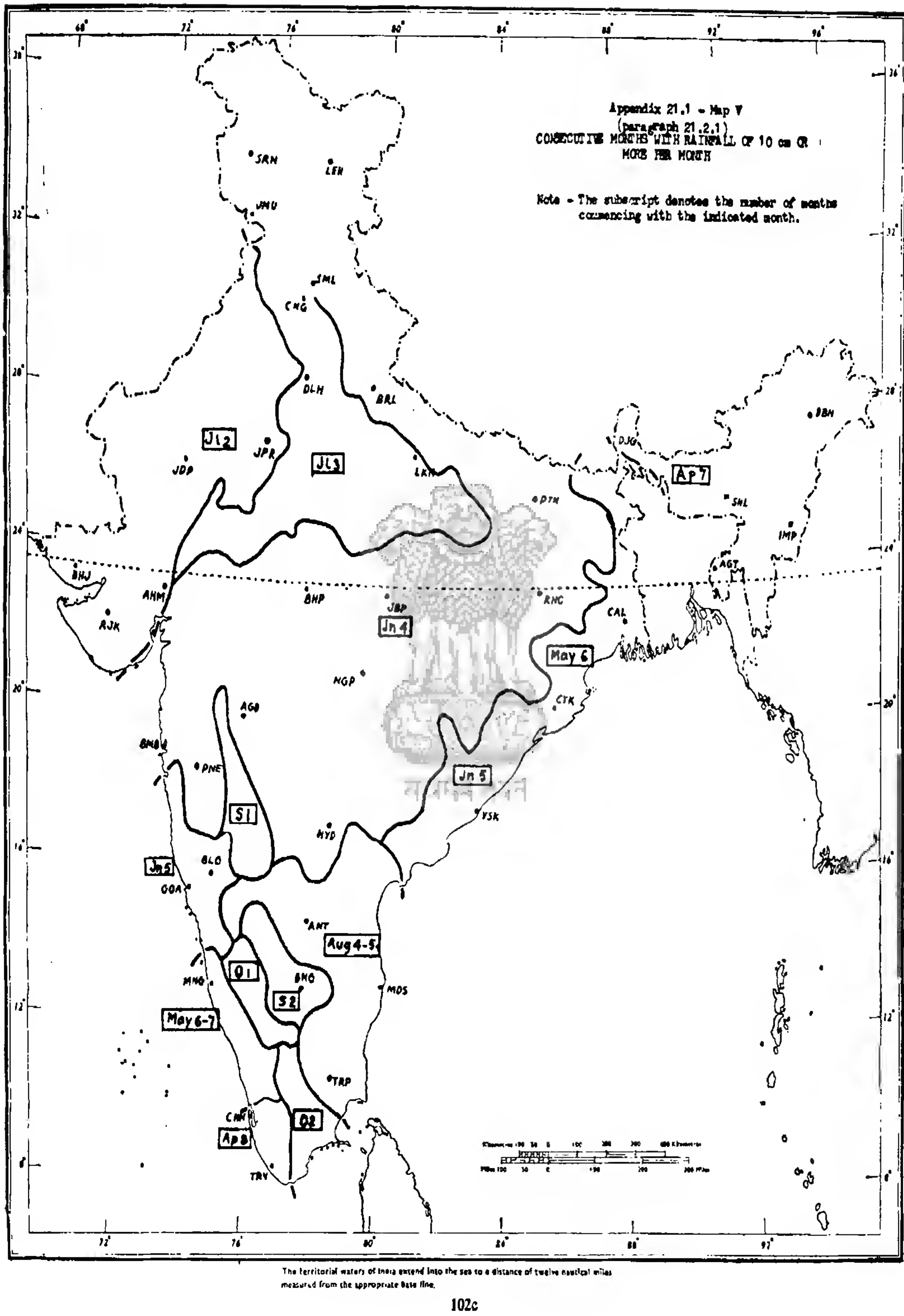
The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

Appendix 21·2 (PARAGRAPH 21·1·8)

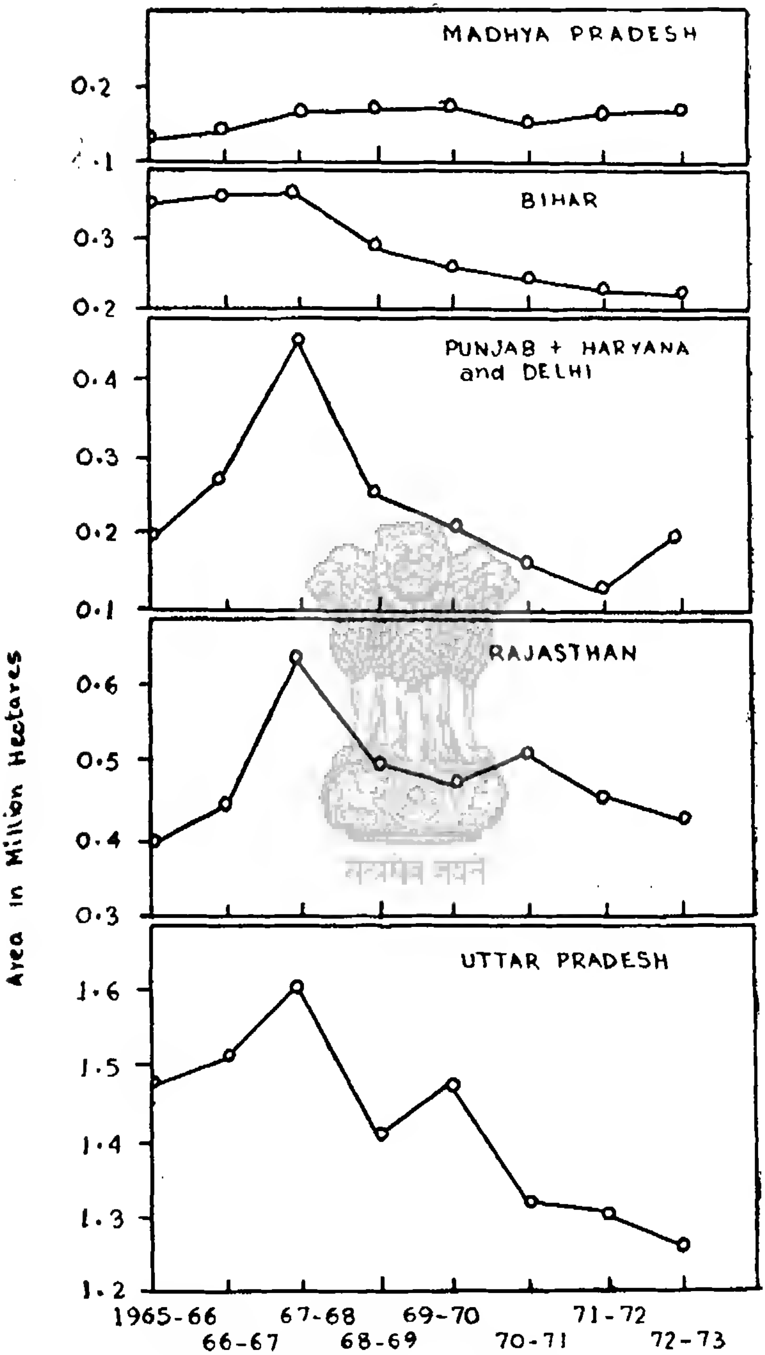


Fig. 1 - Fluctuations in Barley Area.

APPENDIX 21.3—Rabi Cereals

(Paragraph 21.1.1)

Statement I—Estimates of Area, Production and yield of Wheat

years	area (Mha)	production (million tonnes)	yield (tonnes/ha)
1931-32	13.5	9.0	0.7
1941-42	13.6	10.0	0.7
1947-48	8.3	5.3	0.6
1950-51	9.7	6.5	0.7
1960-61	12.9	11.0	0.9
1964-65	13.5	12.3	0.9
1965-66	12.6	10.4	0.8
1966-67	12.9	11.4	0.9
1967-68	15.0	16.5	1.1
1968-69	16.0	18.7	1.2
1969-70	16.6	20.0	1.2
1970-71	18.2	23.8	1.3
1971-72	19.2	26.5	1.4

Note : Estimates for 1931-32 and 1941-42 relate to Undivided India while those for later years relate to Indian Union.

APPENDIX 21.3—Rabi Cereals (Contd.)

(Paragraphs 21.1.1 & 21.1.3)

Statement II—Statewise Estimates of Area, Production and Yield of Wheat (1969-70 to 1971-72)

area......................Mha
production.............million tonnes
yield......................tonnes/ha

State	area		production	yield	per cent of all-India	
	total	per cent irrigated			area	production
1	2	3	4	5	6	7
Uttar Pradesh	5.77	66.2	7.18	1.24	32.1	30.6
Madhya Pradesh	3.36	15.8	2.62	0.78	18.7	11.2
Punjab	2.26	85.4	5.18	2.29	12.5	22.1
Rajasthan	1.42	66.2	1.71	1.20	7.9	7.3
Bihar	1.29	51.2	1.65	1.28	7.2	7.0
Haryana	1.10	81.8	2.29	2.08	6.1	9.7
Maharashtra	0.92	29.3	0.45	0.49	5.1	1.9
Gujarat	0.53	62.3	0.81	1.53	2.9	3.5
West Bengal	0.36	8.3	0.81	2.25	2.0	3.5
Himachal Pradesh	0.35	17.1	0.31	0.89	1.9	1.3
Karnataka	0.33	9.1	0.14	0.42	1.8	0.6
Jammu & Kashmir	0.21	14.3	0.19	0.90	1.2	0.8
Delhi	0.05	80.0	0.08	1.60	0.3	0.3
Assam	0.02	..	0.02	1.00	0.1	0.1
Andhra Pradesh	0.02	40.0	0.01	0.50	0.1	..
Orissa	0.02	25.0	0.02	1.00	0.1	0.1
all-India	18.01	53.2	23.47	1.30	100.0	100.0

Source : Directorate of Economics and Statistics.

APPENDIX 21.3—Rabi Cereals (Contd.)

(Paragraph 21.1.2)

Statement III—Distribution of Wheat Area according to Categories of SW Monsoon months (June—September) Rainfall

(thousand hectares)

State	June—September												
	A4/ A3	A2	A1	B4/ B3	B2	B1	C4/ C3	C2	C1	B4/D3	D-2	E-4	total
Uttar Pradesh	..	1,447	..	234	2,947	118	711	..	..	..	..	..	5,457
Madhya Pradesh	..	2,130	265	..	804	55	..	..	..	..	..	..	3,254
Punjab	..	..	..	..	265	52	701	1,127	..	..	..	..	2,145
Rajasthan	..	40	263	..	459	..	63	273	37	..	158	..	1,293
Bihar	..	626	358	69	107	..	..	..	..	..	..	..	1,160
Haryana	..	..	..	..	90	317	224	380	..	..	..	..	1,011
Maharashtra	2	71	147	..	39	359	95	102	38	..	..	..	853
Gujarat	3	13	123	..	52	284	..	..	29	..	..	..	504
West Bengal	19	52	..	161	..	..	..	..	..	..	..	..	232
Himachal Pradesh	..	220	59	..	14	..	..	16	..	1	..	..	310
Karnataka	..	..	..	..	..	70	85	128	30	..	..	..	313
Jammu & Kashmir	..	57	..	..	99	..	..	..	..	..	..	10	166
Delhi	..	..	..	..	..	..	44	..	..	..	..	..	44
Other Parts	..	12	5	2	..	4	4	..	4	..	..	..	31
all-India	24	4,668	1,220	466	4,876	1,259	1,927	2,026	138	1	158	10	16,773
per cent of total	0.1	27.8	7.3	2.8	29.1	7.5	11.5	12.1	0.8	neg	0.9	0.1	100.0

Note : 1. The analysis is based on average of the district-wise data for 1968-69 to 1970-71.

2. Only such districts have been considered which have an area of 10,000 ha or more under the crop.

3. Explanation of rainfall symbols : A—monthly rainfall 30 cm or more.
B—monthly rainfall 20-30 cm C—monthly rainfall 10-20 cm.
D—monthly rainfall 5-10 cm E—monthly rainfall less than 5 cm.

4. Numeral subscripts to the above symbols denote the number of months in which a particular amount of rainfall is received.

APPENDIX 21.3—Rabi Cereals (Contd.)

(Paragraph 21.1.2)

Statement IV—Distribution of Wheat Area when apportioned to Categories of October Rainfall

(thousand hectares)

States	C	D	E	total
1	2	3	4	5
Uttar Pradesh	..	1,076	4,381	5,457
Madhya Pradesh	..	400	2,854	3,254
Punjab	..	..	2,145	2,145
Rajasthan	..	..	1,293	1,293
Bihar	8	1,082	70	1,160
Haryana	..	..	1,011	1,011
Maharashtra	2	612	239	853
Gujarat	..	3	501	504
West Bengal	157	75	..	232
Himachal Pradesh	..	150	160	310
Karnataka	170	143	..	313
Jammu & Kashmir	..	..	166	166
Delhi	..	..	44	44
Other Parts	8	23	..	31
all-India	345	3,564	12,864	16,773
per unit of total	2.1	21.2	76.7	100.0

Note : 1. Please see Note (1) of Statement III.
2. Please see Note (2) of Statement III.
3. Please see Note (3) of Statement III.

APPENDIX 21.3—Rabi Cereals (Contd.)

(Paragraph 21.1.2)

Statement V—Distribution of Wheat Area according to Categories of November-February Rainfall

(thousand hectares)

State	a4/a3	a2	a1	b2	b1	b4/c3	c2	c1	d4/d3	total
Uttar Pradesh	..	332	..	661	505	211	3,748	..	..	5,457
Madhya Pradesh	..	..	..	117	516	1,333	451	746	91	3,254
Punjab	..	..	138	1,076	..	..	931	..	..	2,145
Rajasthan	..	..	..	..	..	..	260	454	579	1,293
Bihar	..	..	..	15	126	228	716	75	..	1,160
Haryana	..	..	..	90	..	..	921	..	..	1,011
Maharashtra	..	..	..	..	500	192	24	137	..	853
Gujarat	..	..	..	..	..	..	..	28	476	504
West Bengal	..	..	..	22	31	161	18	..	..	232
Himachal Pradesh	16	249	45	..	..	..	..	..	..	310
Karnataka	..	..	2	..	311	..	..	..	..	313
Jammu & Kashmir	35	131	..	..	..	..	..	..	..	166
Delhi	..	..	..	..	..	..	44	..	..	44
Other Parts	..	1	3	2	10	6	9	..	..	31
all-India	51	713	188	1,983	1,999	2,131	7,122	1,440	1,146	16,772
per unit of total	0.3	4.3	1.1	11.8	11.9	12.7	42.5	8.6	6.8	100.0

Note : 1. Please see Note (1) of Statement III.

2. Please see Note (2) of Statement III.

3. Explanations of rainfall symbols:

a—monthly rainfall more than 5 cm.
b—monthly rainfall 2.6 to 5.0 cm.
c—monthly rainfall 1 to 2.5 cm.
d—monthly rainfall less than 1 cm.

4. Please see Note (4) of Statement III.

APPENDIX 21.3—Rabi Cereals (Concld.)

(Paragraph 21.1.8)

Statement VI—Statewise Estimates of Area, Production and Yield of B arley (1969-70—1971-72)

area............Mha
production.........million tonnes
yield.........................tonnes/ha

State	area		production		yield
	actual	% of all-India	actual	% of all-India	
Uttar Pradesh . .	1.37	53	1.41	53	1.03
Rajasthan . . .	0.48	19	0.62	23	1.29
Bihar	0.25	10	0.16	6	0.64
Madhya Pradesh . .	0.17	7	0.16	6	0.94
Punjab, Haryana & Delhi	0.17	7	0.20	7	1.18
total . . .	2.44	95	2.55	95	1.05
West Bengal . . .	0.06	2	0.05	2	0.83
Himachal Pradesh . .	0.04	2	0.05	2	1.25
Jammu & Kashmir . .	0.02	0.8	0.01	0.4	0.50
others	0.02	0.8	0.01	0.4	0.50
all-India . . .	2.58	..	2.67	..	1.03

APPENDIX 21.4—Rice

(Paragraph 21.2.1)

Statement I—Distribution of Rice Area according to Categories of SW Monsoon Months Rainfall

(thousand hectares)

State	rice area under the category	per cent of State/region rice area
(1) A4/A3 category		
N.E. Region (Assam group)	2,371	95
West Bengal (Himalayan)	998	20
Gujarat (Near coast)	86	18
Maharashtra (Konkar)	510	38
Goa	51	100
Karnataka (coastal)	374	33
Kerala	835	95
Dadra Nagar Haveli	9	100
Andamans	8	100
total	5,242	
all-India rice area	36,490	
total of A4/A3 as % of all-India rice area	14	
(2) A2 category		
Jammu & Kashmir	29	12
Himachal Pradesh	80	80
Rajasthan	1	1
Uttar Pradesh	1,933	45
Bihar	3,584	68
Madhya Pradesh	4,194	96
Orissa	3,514	83
West Bengal (Gangetic)	2,626	53
N.E. Region	56	2
Gujarat	58	12
Maharashtra	503	38
total	16,578	
% of all-India	45	

APPENDIX 21.4—Rice (Contd.)

Statement I (contd.)

(thousand hectares)

State	Rice area under the cate-gory	Per cent of State/region rice area
(3) A1-B2 category		
Jammu & Kashmir	42	18
Himachal Pradesh	16	16
Punjab	106	29
Haryana	43	17
Rajasthan	107	88
Uttar Pradesh	2,337	54
Bihar	1,696	32
Madhya Pradesh	115	3
Orissa	744	17
West Bengal	1,315	27
Gujarat	292	60
Maharashtra	95	7
Andhra Pradesh	257	8
Karnataka	158	14
Kerala	40	5
total	7,363	
% of all-India	20	
(4) B1 or less category		
Jammu & Kashmir	164	70
Himachal Pradesh	4	4
Punjab	256	71
Haryana	203	83
Delhi	3	100
Rajasthan	13	11
Uttar Pradesh	65	1
Madhya Pradesh	41	1
N.E. Region	64	3
Gujarat	52	10
Maharashtra	228	17
Andhra Pradesh	3,006	92
Karnataka	594	53
Tamil Nadu	2,584	100
Pondicherry	30	100
total	7,307	
% of all-India	20	

Note : Same as in Appendix 21.3—Statement III.

APPENDIX 21.4—Rice (Contd.)

[Paragraph 21.2.3 (iii)]

Statement II—Area, Production and Yield of Rice in Haryana and Punjab—1965-66 to 1971-72

A—area in Mha
P—production in million tonnes
Y—yield in tonnes/ha

	1965-66			1966-67			1967-68			1968-69		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Haryana	0.19	0.20	1.06	0.19	0.22	1.16	0.22	0.29	1.32	0.22	0.27	1.19
Punjab	0.30	0.30	1.00	0.29	0.34	1.19	0.31	0.41	1.32	0.34	0.46	1.36

	1969-70			1970-71			1971-72		
	A	P	Y	A	P	Y	A	P	Y
Haryana	0.24	0.37	1.54	0.27	0.46	1.71	0.29	0.54	1.84
Punjab	0.38	0.57	1.49	0.39	0.69	1.77	0.45	0.92	2.04

APPENDIX 21.4—Rice (Concld.)

(Paragraph 21.2.4)

Statement III—Area under High Yielding Varieties of Rice—1971-72

(thousand hectares)

State/Region	Total area under rice	Area under HYV of rice	Percentage
N.E. Region	2,625	229	9
West Bengal	4,992	704	14
Bihar	5,206	440	8
Orissa	4,734	253	5
Uttar Pradesh	4,886	994	20
Madhya Pradesh	4,415	400	9
Tamil Nadu	2,668	2,245	84
Andhra Pradesh	2,724	725	27
Karnataka	1,120	160	14
Kerala	872	365	42
Punjab	450	326	72
Haryana	290	70	24
Gujarat	474	60	13
Maharashtra	1,332	232	17
other areas	547	209	39
all-India	37,335	7,412	20

APPENDIX 21.5

(Paragraph 21.2.3)

Statistics of Rice Crop according to Seasons

Rice is a plant for which almost every month is a month of sowing or harvest in some part or the other of this country. This is because temperature and sunshine are not generally the limiting factors in our latitudes representing the tropics and sub-tropics. It is traditionally known to be a time-bound plant rather than season-bound, because of which it has been designated as photo-insensitive. Only some types, which have been introduced very recently, appear to be photo-sensitive. Owing to general independence of the crop from seasons, atleast three well recognised crops of rice in a year have got established in the country. The nomenclature to designate these crops, however, varies widely with place and this leads to considerable confusion in presenting production statistics. On the one hand, the classification is determined by the usually recognised agricultural seasons, viz., rabi, kharif and zaid, which are based on the sowing* date irrespective of the date of harvest, while on the other hand, another kind of classification also prevails, which is based on the season of harvest irrespective of the date of sowing, viz., autumn, winter and summer. The official statistics of the Directorate of Economics and Statistics is presented for autumn, winter, and summer harvested crops as well as for the aggregate annual production from all these crops taken together. This system presents a serious difficulty when it comes to a scientific season-wise study of the crop. For example, autumn and winter respectively represent a crop harvested in October and December, the months representing the peak. The following contingencies are now visualised to explain the points :—

(i) An early 90 days' kharif crop sown in July will be ready for harvest in the beginning of October.

(ii) A late 150 days' kharif crop sown in July will be ready for harvest in the beginning of December.

(iii) A 5-month crop sown in May will be ready for harvest towards September end or October beginning.

Crops (i) and (iii) will be classified under 'autumn' and crop (ii) under 'winter'. The result of this type of grouping becomes apparent when a bulk of the Uttar Pradesh rice crop is pooled under 'autumn' together with the rice crop of Tamil Nadu or adjoining States which are sown not in July but much earlier in the year with the result that the area under kharif rice in Uttar Pradesh denoted by 'winter' crop (which is popularly equated to winter-harvested crop) gets much reduced in official statistics. From the viewpoint of weather, crops (i) and (ii) have much in common with each other in the vegetative phase that determines the stamina of the crop to a large extent. The same is true of Madhya Pradesh and Bihar. The above is a simple example of the classification in question, otherwise very widely varying sowing periods will be found to be put together respectively under autumn, winter and summer crops. This may be seen from Statement I of this appendix.

In order to avoid the inherent difficulties in this system of classification and render data to seasonal interpretation the officially reported statistics has been

*The term in the immediate context includes broadcasting as well as transplanting.

built up according to the following periods of sowing :—

(i) February-May sown crop

(ii) June-September sown crop

(iii) October-January sown crop.

It would have been still better if the sowing periods could be split into smaller units, but the existing production statistics is available for three crop seasons only, which permits only a division into 4 months each. Notwithstanding this defect, even this kind of division does give a fair amount of idea, because the June-September period which accounts for the maximum area has most of its sowings only in a narrow span of July+15 days on either side. The averages of area and production based on data for the years 1969-70 to 1971-72 so built up are presented in Statements II and III of this appendix.

Statement I—Sowing Seasons of Autumn, Winter and Summer Rice

State	autumn	winter	summer
Jammu & Kashmir	April-July	..	..
Himachal Pradesh	..	..	June-July
Punjab . .	May-August	..	May-July
Haryana .	N.A.	N.A.	N.A.
Rajasthan .	July-August	..	..
Uttar Pradesh .	May-July	June-August	January-February
Bihar . .	May-July	July-September	January-February
Madhya Pradesh	10th June-15th Aug.	..	..
Gujarat . .	..	June-August	..
Maharashtra .	..	June-July	..
Karnataka .	May-August	June-October	December-February
Kerala .	April-June	August-October	November-February
Tamil Nadu .	May-November	October-January	February-April
Andhra Pradesh	March-May	June-October	December-February
Orissa . .	May-June	June-August	December-January
West Bengal .	March-June(B) May-July(T)	April-June(B) June-August(T)	.. October-February
Assam . .	Mid February-April	May-July	..
Manipur .	May-June	June-July	..
Tripura . .	March-May	June-August	December-January

B = Broadcasting.

T—Transplantation.

Source : 1967, *Indian Crop Calendar*, (revised and enlarged edition), Directorate of Economics and Statistics.

APPENDIX 21.5 (Contd.)

(Paragraph 21.2.3)

Statement II—Area, Production and Yield of Rice by Periods of Sowing (1969-70 to 1971-72)

area .... thousand hectares
production .... thousand tonnes
yield .... tonnes/ha

State	February—May sown crop			June—September sown crop			October—January sown crop		
	area	production	yield	area	production	yield	area	production	yield
1	2	3	4	5	6	7	8	9	10
Bihar	..	..	..	5,190.9 (97.5)	4,187.8 (95.4)	0.807 (97.9)	133.6 (2.5)	202.0 (4.6)	1.512 (183.5)
West Bengal	786.3 (15.8)	835.5 (13.2)	1.063 (83.7)	3,984.3 (79.9)	4,900.9 (77.4)	1.230 (96.9)	216.9 (4.3)	596.4 (9.4)	2.750 (216.5)
Uttar Pradesh	..	..	..	4,510.8 (96.8)	3,570.0 (97.3)	0.791 (100.5)	150.0 (3.2)	100.0 (2.7)	0.667 (84.8)
Orissa	568.3 (12.3)	310.2 (7.4)	0.546 (59.7)	3,807.1 (83.1)	3,418.3 (81.6)	0.892 (97.7)	208.4 (4.6)	459.4 (11.0)	2.204 (241.1)
Madhya Pradesh	..	..	..	4,372.5 (100.0)	3,521.5 (100.0)	0.805 (100.0)	..	..	..
Andhra Pradesh	1,178.5 (37.0)	1,807.5 (39.3)	1.534 (106.2)	1,276.7 (40.2)	1,743.4 (37.9)	1.366 (94.6)	726.6 (22.8)	1,045.1 (22.8)	1.438 (99.6)
Tamil Nadu	2,066.2 (77.0)	3,834.8 (75.7)	1.856 (98.3)	571.6 (21.3)	1,145.3 (22.6)	2.004 (106.1)	45.3 (1.7)	85.8 (1.7)	1.894 (100.3)

North Eastern States	928.7 (34.8)	759.8 (29.0)	0.818 (83.3)	1,653.8 (62.0)	1,761.7 (67.3)	1.065 (108.5)	85.1 (3.2)	97.4 (3.7)	1.145 (116.6)
Kerala	394.6 (45.2)	537.5 (41.8)	1.362 (92.7)	381.9 (43.7)	554.9 (43.3)	1.453 (98.8)	96.5 (11.1)	190.5 (14.9)	1.974 (134.3)
Maharashtra	..	..	..	1,359.9 (100.0)	1,487.6 (100.0)	1.094 (100.0)	..	..	..
Karnataka	..	..	..	1,033.9 (91.6)	1,936.9 (91.7)	1.873 (100.0)	94.9 (8.4)	176.4 (8.3)	1.859 (99.3)
Gujarat	..	..	..	487.4 (100.0)	520.8 (100.0)	1.069 (100.0)	..	..	..
Punjab	..	..	..	408.1 (100.0)	726.6 (100.0)	1.780 (100.0)	..	..	..
Haryana	..	..	..	266.7 (100.0)	453.7 (100.0)	1.701 (100.0)	..	..	..
Jammu & Kashmir	..	..	..	225.5 (100.0)	416.4 (100.0)	1.847 (100.0)	..	..	..
Rajasthan	..	..	..	122.5 (100.0)	130.8 (100.0)	1.068 (100.0)	..	..	..
Himachal Pradesh	..	..	..	100.1 (100.0)	113.8 (100.0)	1.137 (100.0)	..	..	..
other parts	..	..	..	101.8 (100.0)	167.8 (100.0)	1.648 (100.0)	..	..	..
total	5,922.6 (15.8)	8,085.3 (19.3)	1.365 (122.5)	29,855.5 (79.5)	30,758.2 (73.6)	1.030 (92.5)	1,757.3 (4.7)	2,953.0 (7.1)	1.680 (150.8)

Note : Figures in parenthesis denote the percentage of area, production and yield during each season to total area, production and yield of the crop in the State as given in Statement III of this appendix.

APPENDIX 21.5 (Concld.)

Statement III—Statewise Estimates of Area, Production and Yield of Rice (1969-70 to 1971-72)

area............thousand hectares
production........thousand tonnes
yield ....tonnes/ha

State	area		production		yield	
	actual	% of all-India	actual	% of all-India	actual	% of all-India
1	2	3	4	5	6	7
Bihar . . .	5,324.5	14.2	4,389.8	10.5	0.824	74.0
West Bengal . .	4,987.5	13.3	6,332.8	15.1	1.270	114.0
Uttar Pradesh .	4,660.8	12.4	3,670.0	8.8	0.787	70.6
Orissa . . .	4,583.8	12.2	4,187.9	10.0	0.914	82.0
Madhya Pradesh .	4,372.5	11.7	3,521.5	8.4	0.805	72.3
Andhra Pradesh .	3,181.8	8.5	4,596.0	11.0	1.444	129.6
Tamil Nadu .	2,683.1	7.1	5,065.9	12.1	1.888	169.5
North Eastern States .	2,667.6	7.1	2,618.9	6.3	0.982	88.1
Kerala . . .	873.0	2.3	1,282.9	3.1	1.470	132.0
Maharashtra .	1,359.9	3.6	1,487.6	3.6	1.094	98.2
Karnataka . . .	1,128.8	3.0	2,113.3	5.1	1.872	168.0
Gujarat . . .	487.4	1.3	520.8	1.2	1.069	96.0
Punjab . . .	408.1	1.1	726.6	1.7	1.780	159.8
Haryana . . .	266.7	0.7	453.7	1.1	1.701	152.7
Jammu & Kashmir .	225.5	0.6	416.4	1.0	1.847	165.8
Rajasthan . . .	122.5	0.3	130.8	0.3	1.608	95.9
Himachal Pradesh .	100.1	0.3	113.8	0.3	1.137	102.1
other parts . . .	101.8	0.3	167.8	0.4	1.648	1.479
total . . .	37,535.4	100.0	41,796.5	100.0	1.114	100.0

APPENDIX 21.6—Millets

(Paragraph 21.3.2)

Statement I—Area under Maize according to Categories of SW Monsoon Months Rainfall (1968-69—1970-71)

(thousand hectares)

State	total area	A4/A3	A2	A1	B4/B3	B2	B1	C4/C3	C2	C1	D4/D3	D2	E4
Uttar Pradesh	1,483	..	427	40	25	731	5	255	..	..	..	..	..
Bihar	956	..	407	339	99	111	..	..	..	..	..	..	..
Rajasthan	778	..	35	181	..	412	..	12	138	..	..	..	..
Madhya Pradesh	583	..	276	40	..	236	31	..	..	..	..	..	..
Punjab	524	..	..	..	..	104	35	180	205	..	..	..	..
Gujarat	280	..	..	262	..	14	3	..	..	1	..	..	..
Jammu & Kashmir	251	..	55	..	..	67	..	..	31	..	..	54	44
Himachal Pradesh	256	..	171	50	..	24	..	..	11	..	..	..	..
Andhra Pradesh	243	..	..	..	39	18	168	17	..	1	..	..	..
Haryana	103	..	..	..	..	39	45	8	11	..	..	..	..
Orissa	69	..	63	3	3	..	..	..	..	..	..	..	..
Karnataka	59	1	..	..	..	..	2	25	24	6	1	..	..
Maharashtra	44	5	4	1	..	..	17	5	4	8	..	..	..
Assam	27	24	3	..	..	..	..	..	..	..	..	..	..
Tamil Nadu	14	..	..	..	..	..	..	..	6	8	..	..	..
Manipur	6	6	..	..	..	..	..	..	..	..	..	..	..
Delhi	1	..	..	..	..	..	..	1	..	..	..	..	..
total	5,677	36	1,441	916	166	1,756	306	503	430	24	1	54	44
percentage of total	100.0	0.6	25.4	16.1	2.9	30.9	5.4	8.9	7.6	0.4	neg	1.0	0.8

Note : — 1. The analysis is based on average of the district-wise data for 1968-69 to 1970-71.

2. Only such districts have been considered which have an area of 10,000 ha or more under the crop.

3. Explanation of rainfall symbols :

A—monthly rainfall 30 cm or more.

B—monthly rainfall 20-30 cm.

C—monthly rainfall 10-20 cm.

D—monthly rainfall 5-10 cm.

E—monthly rainfall less than 5 cm.

4. Numeral subscript to the above symbols denote the number of months in which a particular amount of rainfall is received.

APPENDIX 21.6—Millets (Contd.)

(Paragraph 21.3.2)

Statement II—Area under Jowar (Kharif) according to Categories of SW Monsoon Months Rainfall (1968-69—1970-71)

(thousand hectares)

State	total area	A4			B4			C4			D4		
		A3	A2	A1	B3	B2	B1	C3	C2	C1	D3	D2	D1
Maharashtra	2,496	0.5	36	290	..	274	997	723	135	40	..	..	..
Madhya Pradesh	2,263	..	989	225	..	740	309	..	..	..	..	..	..
Rajasthan	1,089	..	132	210	..	251	25	150	299	16	..	6	..
Andhra Pradesh	1,322	..	..	..	24	117	222	488	13	458	..	..	..
Karnataka	1,192	..	..	..	..	..	..	342	167	670	13	..	..
Gujarat	1,130	17	..	141	..	110	711	..	..	151	..	..	..
Uttar Pradesh	761	..	46	..	16	655	8	36	..	..	..	..	..
Tamil Nadu	533	..	..	..	..	..	..	..	244	97	192	..	..
Haryana	216	..	..	..	..	1	..	100	81	..	34	..	..
Orissa	16	..	15	..	1	..	..	..	..	..	..	..	..
Punjab	4	..	..	..	..	..	..	2	2	..	..	..	..
total	11,022	18	1,218	866	41	2,148	2,272	1,841	941	1,432	239	6	..
percentage of total	100.0	0.2	11.0	7.9	0.4	19.5	20.6	16.7	8.5	13.0	2.2	neg.	..

Note :—1. The analysis is based on average of the district-wise data for 1968-69 to 1970-71.

2. Only such districts have been considered which have an area of 10,000 ha or more under the crop.

3. Explanation of rainfall symbols : A—monthly rainfall 30 cm or more. B—monthly rainfall 20-30 cm. C—monthly rainfall 10-20 cm. D—monthly rainfall 5-10 cm. E—monthly rainfall less than 5 cm.

4. Numeral subscripts to the above symbols denote the number of months in which a particular amount of rainfall is received.

APPENDIX 21.6—Millets (Contd.)

(Paragraph 21.3.2)

Statement III—Area under Bajra according to Categories of SW Monsoon Months Rainfall (1968-69—1970-71)

(thousand hectares)

State	total area	A2	A1	B4 / B3	B2	B1	C4 / C3	C2	C1	D4 / D3	D2	E4
Rajasthan	4,670	5	3	..	328	..	165	2,582	739	..	848	..
Maharashtra	2,029	..	..	..	3	333	774	483	436	..	..	..
Gujarat	1,694	..	249	..	314	895	..	..	236	..	..	..
Uttar Pradesh	1,063	62	..	..	610	..	391	..	..	..	..	..
Haryana	894	..	..	..	6	37	503	348	..	..	..	..
Andhra Pradesh	606	..	4	..	..	24	338	39	201	..	..	..
Karnataka	515	..	..	..	..	23	91	63	338	..	..	..
Tamil Nadu	465	..	..	..	..	..	70	186	63	..	76	70
Madhya Pradesh	232	7	2	..	218	5	..	..	..	..	..	..
Punjab	198	..	..	..	2	2	47	149	..	..	..	..
Delhi	21	..	..	..	..	..	21	..	..	..	..	..
Pondicherry	2	..	..	..	..	..	..	2	..	..	..	..
Jammu & Kashmir	16	16	..	..	..	..	..	..	..	..	..	..
total	12,405	90	258	..	1,481	1,317	2,400	3,852	2,013	..	924	70
percentage of total	100.0	0.7	2.1	..	12.0	10.6	19.3	31.1	16.2	..	7.5	0.6

Note :—1. The analysis is based on average of the district-wise data for 1968-69 to 1970-71.

2. Only such districts have been considered which have an area of 10,000 ha or more under the crop.

3. Explanation of rainfall symbols : A—Monthly rainfall 30 cm or more. B—monthly rainfall 20-30 cm. C—monthly rainfall 10-20 cm. D—monthly rainfall 5-10 cm. E—monthly rainfall less than 5 cm.

4. Numeral subscripts to the above symbols denote the number of months in which a particular amount of rainfall is received.

(Paragraph 21.3.2)

APPENDIX 21.6—Millets (Contd.)

Statement IV—Area under Ragi according to Categories of SW Monsoon Months Rainfall

(1968-69—1970-71)

(thousand hectares)

State	total area	A4/A3	A2	A1	B4/B3	B2	B1	C4/C3	C2	C1	D4/D3	D2	E4
Karnataka	887	41	34	..	..	..	105	5	318	249	135	..	..
Tamil Nadu	340	2	..	..	..	..	..	..	226	4	..	98	10
Andhra Pradesh	325	..	..	..	3	..	66	116	49	91	..	..	..
Uttar Pradesh	237	..	121	..	..	116	..	..	..	..	..	..	..
Maharashtra	217	130	10	47	..	..	9	14	7	..	..	..	..
Bihar	178	..	104	61	10	3	..	..	..	..	..	..	..
Orissa	158	..	117	..	41	..	..	..	..	..	..	..	..
Gujarat	55	23	3	28	..	1	..	..	..	..	..	..	..
Madhya Pradesh	19	..	19	..	..	..	..	..	..	..	..	..	..
Himachal Pradesh	14	..	14	..	..	..	..	..	..	..	..	..	..
West Bengal	9	..	9	..	..	..	..	..	..	..	..	..	..
Kerala	5	5	..	..	..	..	..	..	..	..	..	..	..
Dadra & Nagar Haveli	3	3	..	..	..	..	..	..	..	..	..	..	..
Pondicherry	2	..	..	..	..	..	..	..	2	..	..	..	..
total	2,449	204	431	136	54	120	180	135	602	344	135	98	10
percentage of total	100.0	8.3	17.6	5.6	2.2	4.9	7.3	5.5	24.7	14.0	5.5	4.0	0.4

Note :—1. The analysis is based on average of the district-wise data for 1968-69 to 1970-71.

2. Only such districts have been considered which have an area of 10,000 ha or more under the crop.

3. Explanation of rainfall symbols : A—monthly rainfall 30 cm or more. B—monthly rainfall 20-30 cm. C—monthly rainfall 10-20 cm. D—monthly rainfall 5-10 cm. E—monthly rainfall less than 5 cm.

4. Numeral subscripts to the above symbols denote the number of months in which a particular amount of rainfall is received.

APPENDIX 21.6—Millets (Concld.)

(Paragraph 21.3.2)

Statement V—Area under Small Millets according to Categories of SW Monsoon Months Rainfall (1968-69—1970-71)

(thousand hectares)

State	total area	A4 / A3	A2	A1	B4 / B3	B2	B1	C4 / C3	C2	C1	D4 / D3	D2	D1
Madhya Pradesh	1,686	..	1,512	79	..	73	22	..	..	..	..	..	..
Andhra Pradesh	846	..	..	4	3	12	13	238	13	563	..	..	..
Uttar Pradesh	557	..	230	114	47	164	1	1	..	..	..	..	..
Tamil Nadu	474	..	..	..	..	..	..	..	251	14	33	140	36
Karnataka	361	..	..	..	..	..	..	..	211	150	..	..	..
Bihar	228	..	174	41	5	8	..	..	..	..	..	..	..
Maharashtra	205	63	9	..	..	3	67	6	50	7	..	..	..
Orissa	177	..	173	..	4	..	..	..	..	..	..	..	..
Gujarat	153	10	..	115	..	5	22	..	..	1	..	..	..
Rajasthan	72	..	..	21	..	17	25	..	9	..	..	..	..
Himachal Pradesh	29	..	3	11	..	3	..	..	6	..	6	..	..
total	4,788	73	2,101	385	59	285	150	245	540	735	39	140	36
percentage of total	100.0	1.5	43.9	8.0	1.2	6.0	3.1	5.1	11.3	15.4	0.8	2.9	0.8

Notes :—1. The analysis is based on average of the district-wise data for 1968-69 to 1970-71.

2. Only such districts have been considered which have an are of 10,000 ha or more under the crop.

3. Explanation of rainfall symbols : A—monthly rainfall 30 cm or more B—monthly rainfall 20-30 cm C—monthly rainfall 10-20 cm D—monthly rainfall 5-10 cm E—monthly rainfall less than 5 cm.

4. Numeral subscripts to the above symbols denote the number of months in which a particular amount of rainfall is received.

APPENDIX 21.6—Millets (Concld.)

(Paragraph 21.3.2)

Statement VI—Frequency Distribution of Districts according to Different levels of RYI and Categories of SW Monsoon Months Rainfall (1968-69—1970-71)

class intervals for RYI	rainfall													
	A4/A3	A2	A1	B4/B3	B2	B1	C4/C3	C2	C1	D4/D3	D2	D1	E4	
maize														
≤50	..	2	..	..	2	..	..	1	..	..	..	..	..	total districts =125 excluding A4/A3 areas which are very small i.e. less than 10,000 ha per district.
51-90	..	25	7	1	25	2	1	3	..	..	2	..	..	
91-110	..	7	6	..	6	2	1	1	..	..	..	..	1	
111-150	..	4	1	1	5	2	4	5	..	..	..	..	..	
<150	..	1	1	1	1	..	2	2	..	..	..	..	..	
Jowar (kharif)														
≤50	..	..	..	..	2	6	7	5	2	..	..	..	..	total districts=149.
51-90	1	2	4	1	11	3¼	9½	2	5¼	..	..	..	..	
91-110	..	4	2	1	7	6	1	..	3	..	..	..	..	
111-150	..	12	2	..	12	4	5	6	4	2	..	..	..	
>150	..	4	1	..	5	½	1	1½	2½	1½	..	..	..	
bajra														
≤50	..	..	..	..	..	..	..	3	2	..	4	..	..	total districts=118.
51-90	..	..	..	..	6	6	6	6	7	..	..	..	..	

91–110	..	..	..	..	2	1	4	2	..	..	..	..	..	
111–150	..	..	1	..	12	4	9	5	5	..	1	..	1	
>150	..	3	4	..	5	5	6	4	3	..	1	..	..	
ragi														
≤50	..	..	..	..	..	..	..	..	..	..	..	..	..	total districts=52.
51–90	2	5	2	..	..	2	4	2	1	..	..	..	..	
91–110	2	3	3	1	1	1	..	5	3	1	1	..	..	
111–150	2	..	..	..	..	..	..	4	4	..	2	..	..	
>150	..	..	..	1	..	..	..	..	..	..	..	..	..	
small millets														
≤50	..	3	2	..	1	..	2	..	2	..	..	..	..	total districts=95.
51–90	..	23	..	..	2	6	2	1	3	..	..	..	..	
91–110	..	4	..	..	1	..	..	2	..	..	..	..	..	
111–150	1	3	2	..	1	..	..	2	..	1	..	1	..	
>150	2	6	8	2	5	1	..	3	1	..	2	..	..	

RYI=Relative Yield Index with all-India average yield as 100.

22

COMMERCIAL CROPS

This chapter deals with various oilseed crops, sugar crops, tobacco, cotton, jute and other bast fibres. In considering oilseeds, the possibility of the use of some of them in milk substitution has been duly kept in view. Full exploitation of cakes has also been considered, because on this depends the offtake of oilseeds by the crushing industry. In sugar crops, a provision has been made for sugarbeet, which has the promise specially in the northern parts. Fibre crops have been considered against the full realisation of the extent of inroads which the artificial fibres can make in future. Cotton and jute will have to draw more and more upon the irrigation resources for success, whereas many of the oilseeds will have to continue to be grown under rainfed conditions and, therefore, the strategy in their cases will have to be related to dry farming methods.

1 OILSEED CROPS

22.1.1 Oil of vegetable origin is derived not only from oilseed crops but also from cotton seed, rice bran, maize corn, coconut, oil palm and oil bearing herbs, shrubs and trees. Tobacco seed also yields oil, but most of the tobacco varieties are topped*. Among the new crops, soyabean and sunflower are showing a good promise. The already established crops are groundnut, sesamum, niger and castor in the kharif season and brassicas, linseed and safflower in rabi. From area point of view, groundnut is most important occupying about 7 Mha. Next in importance is the brassica group of crops occupying about half as much area as groundnut. The area under sesamum and linseed is about 2 Mha each, while the other crops occupy less than 1 Mha each. The utilisation pattern of these crops is given in Appendix 22.1—Statements I and II. Groundnut brassicas,

*Only virginia tobacco is not topped at present and, therefore, Andhra Pradesh has been producing on an average about 4,000 tonnes of oil annually from this tobacco. However, the trend in Virginia tobacco is also in favour of topping and, therefore, this source of oil is doubtful in future.

sesamum, safflower and niger oils are mainly utilised for edible purpose, while linseed and castor oils are mainly put to non-edible uses (linseed for paints and castor for lubrication). Some quantity of groundnut and sesamum oils also goes for various domestic uses and for the manufacture of soap. The consumption of oils of vegetable origin is expected to increase so much that, despite improvement in yields, it will become imperative to increase area under various oilseed crops to the maximum possible extent.

22.1.2 Oilseeds have been considered all in one group, in the research as well as developmental activities. Research work on the improvement of oilseed crops in India dates back to the early days of the founding of the IARI and it followed the usual historical pattern common to other crops. The Indian Central Oilseeds Committee sponsored research projects in the State Departments of Agriculture, Central institutes and basic universities in the shape of *ad-hoc* schemes. These schemes underwent modifications at two stages, first as integrated schemes and subsequently on a cross commodity integration basis under the title of PIRRCOM (Project for the Intensification of Regional Research on Cotton, Oilseeds and Millets). The All-India Coordinated Research Project on Oilseeds came into being in 1968. A cropwise list of research problems, of which the scientists are already aware is given in Appendix 22.2—Statement I under the three classes, viz., (a) research work already in an advanced stage, (b) research work initiated, but needs to be intensified and (c) research work which is still to be started. The problems are comprehensive enough and it should be clear that these are either already engaging attention or are such which could easily be included in the future five year plans in the usual course in the existing research institutions and agricultural universities. Some of these might even come up in our consideration in the succeeding paragraphs according to the trend of discussion. The important results obtained thus far can be summarised in the following manner :

(i) An extensive interchange of germplasm and breeding material has taken place among the various centres of research on oilseeds. This has facilitated the hybridization programme to increase genetic variation. Each centre is expected to evolve its own finished variety appropriate to its agroclimatic conditions. Besides the yield of oilseeds, the production of oil per unit time and per unit area has also been brought into consideration. About 18 high yielding varieties or hybrids of oilseeds have already been evolved.

(ii) In the oilseed crops, particularly in groundnut and mustard, it has been demonstrated by research groups that

the application of the nitrogenous fertilisers through foliar sprays is desirable both in the context of the saving in fertiliser involved and in its application to unirrigated areas. Nitrogenous fertilisation to groundnut has been on the very low side in spite of research recommendation. This is presumably based on the assumption, that, as a leguminous crop, it does not require exogenous addition of nitrogen, but experiments show that 15 to 40 kg/ha of nitrogen application can prove very useful to this crop. Considerable amount of this nitrogen can be saved if one half of the dose is applied to the soil and other half as a foliar dose. Likewise, in mustard cultivation, application of 40 or 60 kg/ha to the soil followed by 20 kg of nitrogen as foliar gives the same order of yields as 120 kg of nitrogen applied to the soil. There is thus a saving of 40 to 60 kg of nitrogen per hectare. Under rainfed cultivation, when irrigation availability during the second soil application is scarce, the foliar application has an added advantage.

(iii) It has been established in the case of groundnut that yield as well as quality of kernels can be considerably enhanced by the application of minor elements, particularly zinc and boron. Application of gypsum to groundnut crop has been found beneficial at the pegging stage. In the case of other oilseeds, conclusive results have not yet been obtained except for the application of sulphur to rapeseed and mustard. In the case of seasamum, beneficial effect of application of manganese sulphate has been demonstrated in Tamil Nadu.

(iv) In soils with low pH, groundnut yields can be enhanced by periodical application of lime.

(v) Research groups have very effectively demonstrated that, in the kharif oilseeds and particularly in groundnut, weed free fields can produce as high as 100 per cent more yields than those where weeds were allowed to grow. Effective weedicide schedules have also been evolved.

(vi) Productivity of oilseeds could be increased by eliminating patchy stands. Various recommendations have been evolved to ensure full stand in different oilseed crops. In groundnut, seed dressing and soil application of insecticides and fungicides is important; in rapeseed and mustard spray application of insecticides; in linseed growing the rust and wilt resistant varieties; and in castor the release of parasites for the biological control of the pest.

22.1.3 The Oilseeds Development Directorate has drawn up programmes to popularise some of the recent results of researches during the Fifth Plan period. These are mentioned below :

(i) It is envisaged to cover 15 districts in 9 States and saturate at least 75 per cent of their area with a complete package of practices. This will be done by (a) ensuring supply of seeds of improved varieties, (b) making available inputs in time to every farmer, (c) organising plant protection measures on a campaign basis, (d) laying out problem oriented demonstrations, and (e) providing technical advice and services. The area thus covered will be: groundnut 1.36 Mha (Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Punjab and Uttar Pradesh), castor 0.17 Mha (Andhra Pradesh and Gujarat) and brassicas 0.04 Mha (Haryana).

(ii) On foliar application of fertilisers, 10,000 hectares are proposed to be covered under groundnut in Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, Maharashtra, Madhya Pradesh, Uttar Pradesh and Rajasthan. Another 4,000 hectares are proposed to be covered under brassicas in the States of Uttar Pradesh, Rajasthan, Punjab, Haryana and Madhya Pradesh. Insofar as the application of minor elements is concerned, groundnut has been selected to begin with. It is proposed to cover about 50,000 hectares with the application of zinc and/or boron in the States of Andhra Pradesh, Karnataka and Tamil Nadu.

(iii) About 54,000 hectares are proposed to be covered by liming the groundnut fields in some selected districts of the States of West Bengal, Bihar and Orissa.

(iv) On the plant protection side, the following programmes have been envisaged :

Crop to be protected	State	Area to be covered every year (ha)
groundnut against red hairy caterpillar, leaf miner and aphids	Punjab, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu	48,000
groundnut against white grub	Uttar Pradesh, Gujarat, Andhra Pradesh	12,000
brassicas	Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, West Bengal, Assam	210,000

22.1.4 In all the above mentioned programmes, it is significant to notice that there has been too much emphasis only on two crops, viz., groundnut and brassicas. There is need to correct this position so that the yields of all the concerned crops could be increased to maximum possible extent. Many of the known results can be extended with advantage to other oilseed crops and in the case of the major two crops, there is need to extend the results of proven utility to all the area at a much faster rate, because the programme even of the Fifth Plan period covers but a small fraction. The breeding programmes to introduce 'resistance' as well as plant protection work have also to be invigorated, because most of the major oilseed crops are affected by several pests and diseases in field as well as in storage and specific remedies are few. If these defects are removed, there should not be any difficulty to increase production in respect of all crops. In fact, due to the existing neglected state of many of the oilseed crops, their yield standards are very poor and, therefore, there is a vast scope for effecting improvements. This will be indicated properly for different crops when these are examined below individually. To facilitate such an examination, Statewise statistics relating to area and production, based on the three years 1969-70 to 1971-72, are summarised in Appendix 22.1—Statement III for all the crops. Percentage area irrigated during 1969-70 has also been indicated in the case of groundnut and brassicas; other crops are not ordinarily irrigated.

Groundnut

22.1.5 There was a time when special efforts to introduce groundnut were made much the same way as is being done at present for soyabean and sunflower. The crop occupied only 110,000 ha in the beginning of the present century and from that nominal extent it now commands a domineering position in the vegetable fat economy of the country by being grown over an area of 7.23 Mha. The share of the different States in the total area and production of this crop is shown in Appendix 22.1—Statement III. There are 5 major producing States, viz., Gujarat accounting for 24.4 per cent, Andhra Pradesh 20.2 per cent, Tamil Nadu 13.5 per cent, Maharashtra 12.2 per cent and Karnataka 12.0 per cent of all-India area. Madhya Pradesh, Uttar Pradesh, Punjab, Rajasthan and Orissa are other States which together account for 17.3 per cent of area, their individual range being between 1 per cent (Orissa) and 6.2 per cent (Madhya Pradesh). It would be useful to consider the distribution of groundnut area according to different types of rainfall patterns of the south

west monsoon months. It is observed that the area, which lies between A4 and B2 categories of rainfall patterns, is 20.7 per cent, between B1 and CI 74.6 per cent and between D4 and D1 4.2 per cent of the total. The performance of the crop in different rainfall categories of the SW monsoon months has been examined for 117 districts where the crop occupies 10,000 ha or more per district (Appendix 22.1—Statement IV). The chief features which emerge are as follows :

(i) There are in all 47½ districts within A4 to B2 category of rainfall. The Relative Yield Index (RYI) is below 90 in 28½ districts, indicating thereby that the crop suffers due to excess moisture in many places. B2 type has the maximum number of districts in this group viz., 22, out of which 14 have RYI of 90 or less.

(ii) Punjab, Andhra Pradesh and Tamil Nadu take the crop within the rainfall categories of B1 to D1. It is interesting to examine their RYI :

Number of districts in different rainfall patterns commencing with

		B1	C4/C3	C2	C1	D4/D3	D2	D1	
Punjab . .	RL	..	..	..	..	..	..	..	
	RH	1	3	2	..	..	..	..	
Andhra Pardesh	RL	..	2	..	2	..	..	..	
	RH	3	3	1	3	..	..	..	
Tamil Nadu	RL	..	..	..	..	..	..	..	
	RH	..	..	6	1	1	2	1	
total . .	RL	..	2	..	2	..	..	..	31
	RH	4	6	9	4	1	2	1	

RL—RYI 90 or less; RH—RYI more than 90.

All these three States irrigate their crop : Punjab to an extent of 16.4 per cent, Tamil Nadu 13.3 per cent and Andhra Pradesh 12.5 per cent. Punjab's crop is confined between B1 and C2 categories. There are three districts, in which the months of July and August in this State have a rainfall distribution of B1 or C2 and there are 3 other districts which have C4/C3 type of distribution. All the 6 districts have a satisfactory performance which is due to (a) resort to irrigation wherever necessary, (b) taking early maturing varieties which can finish their best part of growth in July and August in B1, C1 or C2 areas and (c) taking the late varieties, which are usually better

yielders, in C4/C3 areas, preferably starting them a little early with irrigation. Insofar as Andhra Pradesh and Tamil Nadu are concerned, their areas get rainfall during the northeast monsoon period also, and, therefore, this gives the high yielding late varieties a better chance for growth. Because of this and support of irrigation in some parts, the performance of the crop is satisfactory in majority of the cases.

(iii) In contrast with Punjab, Andhra Pradesh and Tamil Nadu, there are other three States of Gujarat, Maharashtra and Karnataka which also have their areas falling in B1 to C2 category of rainfall during the SW monsoon period. The frequency distribution of concerned districts in the two ranges of RYI is indicated below :

		B1	C4/C3	C2	
Gujarat	RL	5	..	..	
	RH	2	..	..	
Maharashtra	RL	7	1	2½	
	RH	2	½	..	
Karnataka	RL	1½	1	1½	
	RH	..	1	1	
total	RL	13½	2	4	26
	RH	4	1½	1	

it could be seen that in majority of the cases the RYI is 90 or less.

(iv) Karnataka has 5 groundnut districts in C1 and D4/D3 category of rainfall in the SW monsoon season, CI usually being the month of September. The performance of all the 5 districts is satisfactory. Just like Tamil Nadu and Andhra Pradesh, these also have the advantage of rainfall in the post-monsoon months of October and November.

22.1.6 On the basis of foregoing, one can summarise that the performance of the crop in higher rainfall areas is a little depressed wherever drainage becomes an insurmountable problem. In lower category of rainfall areas lying between B1 and C2 types, where the rainfall is confined to the four months of SW monsoon season, the performance of the crop is usually less than all-India unless supported by some irrigation in times of need. Rainfall is not the only reason for the high or low performance of the crop. It has spread over all kinds of suitable and unsuitable lands in course of time and, therefore,

the soil factor also becomes very important locally. To begin with, the yield of this crop was of the order of 1.2 tonnes/ha in the twenties. The range of productivity got reduced to 1.0 to 0.8 tonnes/ha by early forties and this has varied between 0.5 and 0.8 tonnes/ha between then and now. The present average all-India yield is 0.78 tonnes/ha. The spread of the crop to less fertile and marginal lands is surely one of the causes of this decline.

22.1.7 In future strategy with respect to this crop, one has to take note not only of its continued role in the manufacture of hydrogenated oil, but also in the possible manufacture of vegetable milk. Considering that the crop is already occupying about 7.5 Mha and that it has got extended even to unsuitable areas, very great area increases do not seem to be possible. Even then, the area under this crop in 2000 AD can be kept at 9 Mha. In this further extension, it is going to be difficult to vouchsafe the allotment of only ideal lands to this crop and, therefore, emphasis will have to be laid in future on obtaining maximum possible returns by developing separate agronomic techniques for different soil conditions. Although the existing distribution of the crop has to be accepted as such, yet the fact has to be taken note of that this crop does not do well under high rainfall conditions and, therefore, it will be good if further area is extended in the rainfall category B2 to C4/C3 insofar as the areas served only by SW monsoon are concerned or in areas of the south where September to November usually gets C2 D1 or C1 D2 type of rainfall at least. It will be difficult to provide irrigation to this crop in future too. The maximum irrigation, which can be earmarked for it, will be for an aggregate area of 1.85 Mha only. This provision has been made not for raising the crop exclusively with irrigation water in any particular area but for making a provision of a little timely support at critical times in the growth of the crop, when rainfall happens to fail. One such stage is the time of peg formation. A summer crop of groundnut is known to give better yield, but as the availability of irrigation water is limited for this crop, it could be examined whether the crop could be given an early start in the kharif season with the help of irrigation at least in some project areas. Even though most of the area will continue to be rainfed, it should not be difficult to reach and even slightly improve upon the originally attained standard of 1.2 tonnes/ha. The depression, which has been caused due to cultivation on poor soils can be offset by measures like (a) improvement of drainage in high rainfall areas, (b) water conservation techniques in less rainfall areas, (c) adjustment of growing season to fit into rainfall rhythm of different places, and (d) increasing plant density per unit area. The yield target for 2000 AD may be put at 1.5 tonnes/ha.

Sesamum

22.1.8 The present all-India area under sesamum is 2.38 Mha, production 0.48 million tonnes and yield 0.21 tonnes/ha. The parts of the country which grow this crop are about the same as in the case of groundnut with the difference that the concentration of groundnut is more in the Peninsula, whereas this crop is found more in the north as borne out by Appendix 22.1—Statement III. Rajasthan, Uttar Pradesh and Madhya Pradesh account for about 62 per cent of the all-India area. The crop is taken rainfed almost everywhere. The percentage of area accounted for by different rainfall categories to all-India is : A4 to B2=64, B1 to C1=31 and D4 to D1=2 per cent. The area in the higher rainfall categories predominates in the States of Uttar Pradesh and Madhya Pradesh. There are 154 districts in which the area under this crop is more than 1,000 hectares per district. Their frequency distribution with respect to RYI under different rainfall categories is given in Appendix 22.1—Statement V. The RYI in the higher category of rainfall between A4 and B2 types is less than 90 in 44 districts and greater than 90 in 41 districts, showing that the crop suffers in places due to excess rainfall wherever drainage conditions lack. The crop seems to do well in moderate conditions of rainfall represented by B1 to C1 category. The distribution of districts in this category is summarised below :

States	RL	RH
Rajasthan, Uttar Pradesh, Madhya Pradesh	9	3
Gujarat, Maharashtra	1	19
Karnataka, Andhra Pradesh, Tamil Nadu	9	23
total	19	45

RL—RYI of 90 or less. RH—RYI of more than 90.

There is one district in Karnataka and 4 in Tamil Nadu which fall in D4 to D1 and their RYI is above 90. The south, as usual, has the advantage of September to November rainfall also. This suits the crop to be taken in rabi season. In fact, this crop is raised in all the three seasons in some parts. It can suit as a filler crop in many areas depending upon agroclimate conditions and crop rotations. The oil needs of the country will make it necessary to increase the area under this crop and this could be done in the rainfall zones covered by B1 to C1 types of patterns. The total area under this crop could

be aimed at a level of 3 Mha. There is room for making substantial improvement in the yield standards of the crop and it should be possible to attain an average all-India standard at least thrice the present level, i.e., 0.60 tonnes/ha by 2000 AD. In this endeavour, maximum attention will be needed in all parts of the country and the main strategy will once again have to be that of improving drainage conditions in high rainfall areas and better utilisation of rainfall facilities elsewhere.

Niger

22.1.9 Madhya Pradesh has about 50 per cent of the all-India area under niger but the yield is only 0.18 tonnes/ha. Bihar, Orissa and Maharashtra are also important producing States. Bihar and Orissa yields are of the order of 0.4 tonnes/ha. These four States put together account for about 92-93 per cent of area and production (Appendix 22.1—Statement III). The present area of 0.48 Mha could be trebled and stabilized at 1.5 Mha by extending cultivation into the wheat fallows in Madhya Pradesh. The all-India average yield is 0.24 tonnes/ha. The aim should be to double it, which in terms of Madhya Pradesh will mean near about trebling its yield. Ethiopia grows a better yielding variety of niger, which could be tried under Indian conditions.

Castor

22.1.10 There are no limitations to castor growing anywhere in India, but as borne out by Statement III of Appendix 22.1, some specialised pockets have developed mostly in Andhra Pradesh and to a much lesser extent in Gujarat. Andhra Pradesh has 70 per cent of all-India area, but its average yield is only 0.20 tonnes/ha. The yield in Andhra Pradesh has been about this figure between 1966-67 and 1972-73. In 1973-74, the yield rose to 0.32 tonnes/ha, but it is difficult to draw any inference just on one or two years' performance and even otherwise the latest achievement is much lower than what is obtainable in Gujarat. Gujarat has 11 per cent of all-India area and its yield is 0.72 tonnes/ha, the all-India average being 0.34 tonnes/ha. India is one of the major producers of castor seed ranking next only to Brazil, accounting for about 28 per cent of the world production, and for this reason, castor plays a significant role in the country's export trade. We have envisaged increased silkworm rearing activity vide Chapter 26 on Sericulture and in this context also, more and more castor will be required to be grown for feeding

criworms. It is necessary to increase the present area of 0.42 Mha under castor to 1 Mha. It is also necessary to effect improvement in the yielding capacity of the crop. Brazil already records yields of 1 tonnes/ha or more and even in India, some of the newly evolved short duration varieties like Aruna, GCH-3, SA-I and SA-II possess a similar potential, the duration of maturity being 135—150 days. Gujarat and Orissa already record yields of about 3/4 of a tonne per hectare and, therefore, the future targets can easily be kept at 1 tonnes/hectare and, therefore, the future targets can easily be kept at 1 tonnes/ha.

Brassicas

22.1.11 The oil bearing members of the brassica group are cultivated in the entire country outside the Peninsula, with Uttar Pradesh as the most important State in this regard (Appendix 22.1—Statement III). The use of this oil for various domestic, edible as well as non-edible purposes is very common in the belt comprising Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and Assam. The total area under this crop (3.36 Mha) comes only next in importance to groundnut. Although the cultivation of brassicas synchronizes with the main wheat belt in general, yet Uttar Pradesh alone accounts for about 65 per cent of the all-India area. Wheat-brassica mixture is a prevalent crop combination and wherever it is so taken, this crop automatically gets the advantage of tillage, irrigation and manuring as accorded to wheat. When a pure crop is taken, the practice of irrigation varies in places; it is irrigated somewhere and not irrigated elsewhere. The proportion of irrigated area varies between 30—60 per cent in Rajasthan, Haryana and Punjab. The irrigated area under this crop in Uttar Pradesh is insignificant. Herein lies one major constraint, removal of which can contribute considerably towards raising the production levels. The irrigation target for this crop could be put at 50 per cent of the total area as against a mere 8 per cent as at present. With this favourable factor accompanied by other scientific improvements, it should be possible to double the yield level which has not gone beyond half a tonne per hectare on the average in the recent past. The area could be stabilised at 4 Mha representing just a small increase of 0.6 Mha. It is natural to expect that in consonance with the dominant position of the crop in Uttar Pradesh, at least half of this crop should be raised under irrigated conditions and farmers will not grudge it because of the price differential in favour of mustard group of crops in comparison with wheat. The mustard prices (Kanpur) have been Rs. 100 to 125 per quintal higher than wheat (Hapur) between 1969-70 and 1972-73.

Linseed

22.1.12 The area occupied by this crop is 1.88 Mha. It is grown in most parts of the country, but the major States are Uttar Pradesh, Madhya Pradesh and Maharashtra as borne out by Appendix 22.1—Statement III. It is mostly used for inedible purposes and there is room for increasing its yield to about half-a-tonne per ha (i.e., twice the present level), owing to which it is not necessary to effect much increase in area. The area could be kept at 2 Mha, which is about the same as at present.

Safflower

22.1.13 The quality of safflower oil is rated to be high for edible purposes because of very low poly unsaturated fatty acid content. The oil is often used even for adulterating *ghee* and sesamum oil, Although grown in many parts of the country. Maharashtra has the largest area followed by Karnataka and Andhra Pradesh (Appendix 22.1—Statement III). It comes up well under rainfed as well as irrigated conditions but is usually taken on dry lands. Safflower sown with the backing of September moisture has great potential for area expansion in lands, which are generally left fallow at present during rabi season, e.g., paddy fields after the harvest of paddy. It can be a fit substitute for lathyrus in Madhya Pradesh, Bihar and West Bengal. The area can easily be increased to 2.0 Mha and the yield 0.5 tonnes/ha (present figures are 0.59 ha and 0.24 tonnes/ha respectively). It will not be difficult to achieve the yield target with the development of better varieties in future suitable for different tracts and conditions.

Soyabean

22.1.14 Soyabean is a crop of dual advantage. It has 15—20 per cent of oil. It is highly rich in protein content also (40 per cent). This crop is very popular in the USA and China. The main problem here is that the exotic varieties like Bragg have poor seed viability because of skin cracking. There is also the further problem that this variety has to be sustained by the oil and the soyameal market. Whereas oil can be easily marketed, the meal at present is utilisable only in particular trades and the bulk of it has to be exported as cattle feed. Therefore, world cattle feed market controls the price of soyabean. Thus, the profits are uncertain on the one hand and the cost of cultivation is high on the other, being about Rs. 800 per hectare; both these factors act as a deterrent for the crop to be adopted in general. The cost of cultivation is high because of high seed rate (75 kg per

hectare) coupled with high price of seed (about Rs. 240 per quintal). In addition, the cost of specific rhizobial culture, which is essential to inoculate the soil for the success of the crop, also increases the cost of cultivation. Some time back there was even dearth of the needed *Rhizobium* strain. However, the IARI is now capable of producing the necessary quantity of this culture. Another reason to hold up the popularity of the crop is that, but for a few manufacturers of baby food or protein biscuits, the protein aspect of soyabean has not been fully utilised in this country, which also limits the margin of profit.

22.1.15 The Government has been providing 25 per cent subsidy on the cost of seed and insecticide. It has been rendering free technical advice on cultivation techniques. The Government has also been giving some price support for the crop. It is often argued that some more incentives and concessions should be provided by the Government for the successful adoption of this crop in the country. We are of the opinion that the crop should be made to develop purely on the basis of economics and utility. Besides the disadvantages with the exotic varieties, which have already been mentioned above, the basic fact which has often been overlooked is that the exotic varieties are not easily consumed as pulses in the country. Thus, these varieties suffer when there is a glut in the oil or meal market, as they also lack the alternative of disposal as pulse. The effect of this is well reflected in the fact that the area, which was actually covered by the crop during 1973-74, was only 100,000 ha as against the target of 400,000 ha fixed for the States of Madhya Pradesh, Maharashtra, Gujarat and Uttar Pradesh as a part of a Centrally sponsored programme. The remedy lies in changing the strategy from introducing the exotic varieties to selecting some of the indigenous varieties and making them popular. There is a lot of soyabean production in the hilly areas of this country, specially in the Himalayan hills. This soyabean is well relished as a pulse by the hill population. Recently, some varieties from the hills were introduced with success in the black cotton soil of Madhya Pradesh; this provides a ray of hope and a new direction to plan future strategy. Selecting indigenous varieties and effecting improvement in them is well worth a trial. Alongside, more avenues of soyabean utilisation have also to be found out. It will be desirable to think of measures whereby people are able to accept wheat flour duly fortified with soyabean flour. Such blended mixtures may prove better from nutrition point of view than pure wheat flour. Putting to use soyabean flour and meal in confectionery articles is another direction. Then, soyabean has a potential to be utilised as a substitute for milk. Soyabean constituents are such that it is possible to prepare a liquid similar to milk in consistency, composition and other properties. Even curd

of good quality can be prepared from soyabean milk. Successful trials have already been made in this regard on soyabean. What remains to be done is that research, production and publicity work relating to soyabean milk should be made as widespread as possible.

22.1.16 Just like blackgram, soyabean is also comparatively a high water requiring crop fitting satisfactorily in A2—B2 categories of rainfall. It can serve as one of the alternatives to paddy wherever rainfall is high enough but not sufficient for paddy. It is worth trying as a substitute to pulses like horsegram wherever irrigation facility could be made available even in otherwise less rainy areas. An area of one million ha can be earmarked for this crop. Assuming an yield of 1 tonne/ha, the yield from the crop will be 1 million tonnes. The entire crop will not be available for crushing because of allowance for seed, wastage and even direct use for various edible purposes including soyabean milk. One may assume that 50 per cent of the produce may be available for crushing. With an oil recovery of 15 per cent the oil yield from this source will be 75,000 tonnes. In order not to give any chance to setback in future, the researchers will have to see that the future varieties are resistant to diseases, specially mosaic, to which the existing varieties have been found to be prone despite the best efforts of institutions like Govind Ballabh (GB) Pant University of Science and Technology, Pantnagar, Jawaharlal Nehru Krishi (J N K) Vishwa Vidyalaya, Jabalpur and the All-India Coordinated Research Project on Soyabean.

Sunflower

22.1.17 Floral varieties of sunflower have always been known in the country, but the significance of this plant as a source of oil came to foreground only when oil-rich Russian varieties attracted attention. Seed of oil-rich varieties has an oil content as high as 45 to 50 per cent. The quality of oil is also good even from nutritional considerations on account of having a high percentage of poly unsaturated fatty acids (60 per cent). It has a low seed rate of 10 kg per hectare. The crop has a short duration of about 90 days and it can grow any time of the year. It is adaptable to different soil conditions and can grow even under saline conditions. The plant grows luxuriantly under irrigated conditions, but it can also give a fair degree of performance under stress conditions. Its yield with irrigation is as high as 3.9 tonnes per hectare. It can be grown satisfactorily as a kharif crop in areas where rainfall is 20 cm or more per month in one or two months out of a total of four rainy months of June-September. Its seed can be crushed in conventional village *ghanies,* baby mills and large-scale extraction plants. Owing to these advantages, the crop has an

easy acceptance.

22.1.18 Two quintals of 4 varieties of sunflower seed were imported in 1968-69 from the USSR. In a matter of 4 years, the crop has come to occupy an area of 80,000 ha and it is expected to cover 930,000 ha by the end of the Fifth Plan. However, poor yield derived from the crop at present is a handicap to farmers. Small number of seeds, which set in the floral heads, does not prove to be very viable, because of which the germination percentage is also reduced. Seed-setting is found to improve with increased bee-pollination and for this purpose, beekeeping is made a necessary accompaniment to sunflower cultivation in Russia. Some preliminary data collected by the Directorate of Beekeeping, Bombay (Khadi & Village Industries Commission) also tends to indicate the same. This is an encouraging result which requires to be thoroughly established with extensive experimentation under Indian conditions. It is likely that the problem of viability of seeds may be linked with the efficiency of pollination and, therefore, this also needs study alongside. The scope of the study could be extended to include the possibility of exploring other related problems, on which may depend an answer to better yields and better quality. The oil content of seed could also profitably be increased through further breeding efforts. It is pertinent to mention at this stage that, if effective cross pollination is one of the major factors in bettering yield standards, our recommendation in Chapter 27 on Apiculture to take all possible steps for the protection and proliferation of honeybees might prove very beneficial, when implemented. The popularity of this crop is bound to grow with these steps. Consequently, a target area of 2.0 Mha should be earmarked for it. It may, however, be noted that it would not be possible to allocate more than 0.75 Mha of irrigated area to this crop. Therefore, the remaining area of 1.25 Mha will have to be taken rainfed with the possibility of sunflower being raised as an early kharif crop in general (wherever possible) and late kharif crop with the help of September-October rains in the south. Considering (a) an yield level of 1 tonne/ha, (b) 90 per cent of the produce being available for crushing, and (c) oil recovery of 40 per cent, the oil yield will be 720,000 tonnes.

A Composite Look

22.1.19 The existing and proposed position of area and yield of oilseed crops is put at one place in Appendix 22.1—Statement VI. The quantity of oil which will accrue from the field crops has been calculated in Appendix 22.1—Statement VII. It may be seen that an area of about 9 million hectares has been added to the existing area under oilseed crops and the yield level has generally been raised

by two to three times. The total oil recovery from the field crops is expected to be 6.42 million tonnes. Another 3.26 million tonnes could come from the exploitation of cotton seed, rice bran, maize and bajra, coconut, oil palm and nature grown trees and shrubs as explained in Appendix 22.1—Statement VIII. It has to be noted in the case of field crops that neither further area increase is possible, because of the requirements of many other crops, nor there is possibility of further bettering the yield standards keeping in view that many of the oilseed crops will continue to be raised rainfed and groundnut and brassicas have already engaged ample attention from research workers. Therefore, it is imperative that relentless efforts are made to tap the sources other than field crops. Some of the important points to be borne in mind in this regard are considered below :

Cotton Seed

(i) The Government had given upto February, 1975 an excise rebate of Rs. 200 to 250 per tonne up to 30 per cent of the utilisation of the cotton seed oil in hydrogenated oil industry. This has been revised with effect from 1-3-1975 to range from Rs. 200 to 250 for utilisation percentages of 30 to 50 and Rs. 200 for utilisation of more than 50 per cent of cotton seed oil. Despite such an impetus, the seed crushed has been only about 30 per cent of the total availability in recent years. There are two reasons for this kind of low utilisation. Firstly, the Indian farmer is accustomed to feed his animals, specially milch animals, with whole cotton seed and, therefore, he does not release much quantity for other use. Secondly, there is the problem of disposal of cake. The Government of India had been giving liberal export entitlement or it has given even cash incentives recently to enable the exporters to compete in the world market. Such concessions were withdrawn from April 1971, because of which the required quantity of cake could not be exported. This had an adverse effect on oil production within the country. One hundred and ten thousand tonnes of oil was produced in 1970, whereas the quantity produced in 1972 was only 75,000 tonnes. Both these drawbacks can be rectified to a very great extent just by one single step and that is through the popularisation of cotton seed cake for livestock feeding instead of the whole seed. This lies in the sphere of extension agencies both of the agricultural universities as well as of the State

Departments of Agriculture and Animal Husbandry, and they must not leave any stone unturned in popularising cakes for livestock feeding. It will be of interest to note that feeding trials with cake have shown that it is not inferior to seed. In fact, it is not desirable to feed livestock with seed, because it causes stomach disorder due to scouring. The decorticated cake contains 34 to 38 per cent digestible proteins as compared to 17 per cent in the seed.

Rice Bran

(ii) About 6 per cent of the total available quantity of bran is utilised at present for oil extraction. This is despite many fiscal incentives, which are offered at present for the use of rice bran oil. In soap manufacture, a suitable excise rebate per tonne of soap is offered for each additional percentage point increase in the use of rice bran oil over a specified level. It was Rs. 1.50 per tonne of soap for each additional percentage point increase over 15 per cent upto July, 1973. With effect from March 1975, it is Rs. 3.50 per tonne of soap over 25 per cent and in the intervening period it has risen even to Rs. 7.50 for a percentage level of 15. In the manufacture of hydrogenated oil, an excise rebate of Rs. 100 per tonne of oil used is offered subject to its being in excess of 1 per cent. Here again, a major factor which is responsible for denying the bulk of the quantity for oil extraction is the practice of feeding bran to livestock and it is forgotten once again that the deoiled bran in itself constitutes a rich concentrate for cattle and poultry. However, it is appalling to note that there is no market even for the modest quantities of deoiled bran which becomes available at present from the industry. Deoiled bran is being exported currently, the quantity was nearly 70,000 tonnes in 1968 as against a production of 93,000 tonnes. Just like cottonseed cake, popularisation of feeding livestock with deoiled bran must also be an item in the programmes of extension agencies.

Millet Oil

(iii) There is no difficulty envisaged in the case of maize. Maize germ, which comes out as a byproduct of the starch

industry, is even now utilised for oil extraction. As already indicated in the beginning, bajra does present a potential for increasing use for oil extraction and this depends how far deoiled bajra could be popularised successfully in human diet as well as for livestock feeding, specially poultry birds.

Nature Grown Trees and Shrubs

(iv) Various aspects of oil yielding trees and shrubs including methods of collection, crushing facilities and also the scope of utilisation for industrial purposes were examined by a Sub-Committee set up for the purpose in 1970 by the Ministry of Agriculture. The Committee observed that oils produced from *mahua, neem, karanja, kusum, khakan* and *sal* etc., could be utilised satisfactorily by the soap, paint and varnish industries, thereby releasing equivalent amount of groundnut oil for direct consumption. It laid emphasis upon the utilisation of the oil potential available from oil yielding trees and shrubs in order to fill the gap in the demand and supply of vegetable oils. This subject has been dealt with in detail in Chapter 43 on Minor Forest Produce.

Cakes and Meals

22.1.20 The full utilisation of cakes and meals is going to determine the prospects of the oil crushing industry and hence of the production programmes of oilseeds in future. An idea of the total availability of cakes and meals can be had from the following approximate calculations :

(million tonnes)

	Oil production	Per cent oil recovery	Cake/meal production
oilseed field crops	6.42	25	19.26
cotton seed and rice bran	1.61	15	9.12
millets	0.34	3	10.99
plantation crops	0.11	50	0.11
nature grown trees and shrubs	1.20	15	6.80
			46.28

Assuming even a realisation of 90 per cent of this estimate in practice after allowing for wastage etc., the overall production of cake/meal can be expected to be of the order of 42 million tonnes. The disposal of such a huge quantity is going to be a big problem unless properly planned. Some suggestions in this regard are given below :

(i) The maximum utilisation will have to be in livestock feeding. The groundnut cake and soyabean meal offer some scope even for human consumption in confectionery articles.

(ii) Many kinds of cakes hold promise for use as germicidal and pest repellent agents and, therefore, are required to be evaluated for such properties in an exhaustive and systematic manner. This specially applies to wild plants and trees. Other uses also require to be established.

(iii) Utilisation of cakes as manure is limited to a few species only. However, farmers are aware of the use of cakes like *mahua* for this purpose. *Neem* cake is preferred in mixture with urea, because it slows down the release of nitrogen, which otherwise can be lost unutilised. Proper experiments are necessary to be conducted with all kinds of cakes in order to establish their usefulness as manure. Further, in order to make them popular universally, concerted extension efforts will also be required.

(iv) There will have to be a proper balancing of internal demand and export. Sometimes, there is a slump in exports. This has already been referred to earlier in the case of cotton seed and rice bran. Such contingencies can be avoided by an alert export machinery and/or through alternative means of utilisation, which should be thought of and kept ready in advance.

Organisation

22.1.21 The subject of oil crops and oil bearing vegetation is at present dealt with in a very scattered manner. Field crops are looked after by the Department of Agriculture. There is no single proper agency to deal with subsidiary materials like cotton seed and rice bran etc. There is no integrated governmental set up from the Central to State level to deal with seed collection from natural vegetation. The Khadi & Village Industries Commission has been making endeavours in this direction, which require to be encouraged and supported, in a big way through governmental involvement. A plantation crop like oil palm has to be established firmly. There is no specific technological laboratory for oilseeds, the work is done on an *ad hoc* basis

scattered over many laboratories. Cakes' disposal is scattered and disorganised and it operates largely through private involvement without any integrated policy to effect harmony between production and utilisation. All these defects are required to be removed and for doing this, there is need for four well coordinated wings one each for (a) field crops, (b) subsidiary oil bearing products of field crops, (c) nature grown oil bearing plants and (d) byproducts of oil industry. These wings are necessary both on the research as well as production side, i.e., in the ICAR as well as in the Union Ministry of Agriculture and Irrigation under the Directorate of Oilseeds Development. A similar operational set up has to be created in the State Departments of Agriculture with necessary involvement of the agricultural universities on research side. Another deficiency, which requires to be removed, pertains to making available the facility of technological studies and analysis relating to oilseeds and their products to the oil industry just in the same way as the Cotton and Jute Technological Laboratories cater to the needs of their respective industries. At present, the oil mills have to get their problems solved not at one institute but at many universities and other laboratories on an *ad hoc* basis. Therefore, it is desirable that a Central Technological Laboratory for oilseeds and their byproducts should be created under the ICAR.

22.1.22 The diversity and dispersal of oilseeds in the country are of such a nature that any general all-India coordination of the type that exists today renders difficult giving separate attention to each kind. What can prove more effective is that each State should feel its own responsibility for research as well as developmental work in regard to the oilseeds occurring in its jurisdiction. The first ladder of coordination should relate to such contiguous States which have common species and common problems. The Central coordination should be reduced to problems of all-India nature only. The Oilseeds Development Council at the Centre could be converted into a broad-based apex body for such central objectives. It could have representatives from the States, ICAR, Union Ministries of Agriculture and Irrigation, Industries and Commerce, Forest Research Institute, Dehra Dun, Khadi and Village Industries Commission and the Oil Millers' Association or similar bodies. There has to be a very active and meaningful liaison among the ICAR and the Ministries of Agriculture and Irrigation, Industry & Civil Supplies and Commerce through the Council or even directly also. It is necessary that an apex body on the lines of the Centre is also created in every State. It could have representatives of the agricultural university, Departments of Agriculture, Horticulture, Plantation Crops (if any), Forest, Industries, Khadi and Village Industries Board, representatives of oil industry and

growers. It is this body which could represent a State on the Central apex body. The inter-State cooperation and coordination among the contiguous States could also be performed at the level of State apex bodies.

2 SUGAR CROPS

Sugarcane

22.2.1 Notable sweetening agents of vegetable origin are sugarcane, sugarbeet, palms and sorghum. Each of these is considered in this section. Sugar yielding crop that really matters in this country is sugarcane. Government has always given special attention to this crop for sugar production. There has been fiscal protection since 1932 commencing with the 1930 Report of the Indian Tariff Board. Even in the recent two decades the growth of factories has been nearly 1½ times and the production of white sugar has risen three-folds; the number of sugar factories going up from 138 in 1950-51 to 216 in 1970-71 and production rose from 1.1 to 3.7 million tonnes in the same period. The distribution of factories in 1970-71 was : Uttar Pradesh 71, Bihar 27, Haryana 3, Punjab 6, Maharashtra 41, Andhra Pradesh 19, Karnataka 11, Tamil Nadu 15, others 23. The sugar licensing policy of the Government encouraged cooperative sugar mills, particularly in the Peninsula and the number of such mills in 1970-71 was 81. White sugar represents only about 28 per cent of the total cane utilisation, the maximum quantity, i.e., 60 per cent of cane being used in the manufacture of *gur* and *khandsari* sugar and the remaining 12 per cent is accountable by seed, chewing and wastage. *Gur* and *Khandsari* represent respectively the cottage and small scale industries engaged in manufacture of sugar but they are not run on organised lines.

22.2.2 Sugarcane crop is so important because of the universal need for gur or sugar that it is grown atleast to a little extent almost in every part of the country except for extreme north or high hills. Ninety per cent of the area and production, however, is in the 8 States—four in the north consisting of Bihar, Uttar Pradesh, Haryana and Punjab and four in the Peninsula, viz., Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. The all-India averages of area and yield for the period 1965-66 to 1971-72 are 2.50 Mha and 46 tonnes/ha respectively and even in the recent three years ending 1971-72, these have not undergone much change, the values being 2.59 Mha and 49 tonnes/ha respectively. The state-wise averages of area and production

based on seven years data i.e. 1965-66 to 1971-72 are given in Table 22.1. Uttar Pradesh alone accounts for 51 per cent of area and 43 per cent of production. When an examination is made from the angle of outturn per hectare, it is evident that the yield are much higher in the Peninsula as compared to those of elsewhere in the country. The average for Maharashtra is of the order of 60 tonnes/ha, for Andhra Pradesh and Tamil Nadu, it is of the order of 80 tonnes/ha, while Karnataka has attained an average of 90 tonnes/ha. The yield in Uttar Pradesh approximates to 40 tonnes/ha and, but for Bihar where it is a little depressed even further, all other States have a yield of the same order.

TABLE 22.1

Area and Production of Sugarcane
(1965-66 to 1971-72)

area = Mha
production = million tonnes
yield = tonnes/hectare

State	Area		Production		Yield
	actual	% of all India	actual	% of all-India	
Uttar Pradesh . .	1.27	51	50	43	39
Haryana . . .	0.15	6	6	5	40
Bihar	0.15	6	5	4	33
Punjab	0.14	6	5	4	36
total . . .	1.71	69	66	56	39
Maharashtra . . .	0.19	8	12	10	63
Andhra Pradesh . .	0.13	5	10	9	77
Tamil Nadu . . .	0.12	5	10	9	83
Karnataka . . .	0.09	3	8	7	89
total . . .	0.53	21	40	35	75
other States . . .	0.26	10	10	9	38
total all-India .	2.50		116		46

22.2.3 Practically all the States resort to ratooning. This is specially so in the case of Uttar Pradesh and Bihar. The following figures collected from the Central Directorate of Sugarcane Development will

reveal that the area under ratoon crop is of the order of 30 per cent in these two States :

(million hectares)

	Uttar Pradesh		Bihar	
	total area under sugarcane	area under ratoon	total area under sugarcane	area under ratoon
1966-67	1.49	0.49	0.15	0.05
1967-68	1.19	0.40	0.12	0.04
1968-69	1.00	0.30	0.15	0.05
1969-70	1.20	0.33	0.17	0.06
average	1.22	0.38	0.15	0.05
ratoon as per cent of total area		31		33

The yield figures are readily available only for the reserved areas of Uttar Pradesh, i.e., for the areas which are specially earmarked for sugarcane production for the sugar industry. These values have been examined for a 15-year period ending 1971-72 and it is seen that, whereas the yield of the plant crop has been of the order of 45 tonnes/ha the ratoon crop has yielded on the average only 33 tonnes/ha. This should suffice to impress the depressing effect of a ratoon crop on the overall yields which are reported in the official statistics of area and production. If the yield of plant crop even in the existing circumstances is considered separately, it does not present as dismal a picture for Uttar Pradesh and adjoining northern tracts as it appears to be on the face value. Further, the duration of sugarcane crop in Uttar Pradesh and other northern areas is 9 to 10 months only. As against this, the crop in the Peninsula stretches over a period ranging from 12 to 18 months. Therefore, if the yielding capacity is reduced to an identical unit scale of time, this may also reduce the apparent disparity between the north and south. One has also to recognise that the canes which are suited to north are thin, while those which are prevalent in the south are thick noble canes. The crop in the north is raised with less doses of manure and irrigation as compared to south. Keeping all these points in view, it has to be recognised that sugarcane cultivation in India represents 2 different systems and must go hand in hand in a complementary manner, specially because the vast expanse of area and irrigation facilities which are available for the crop in Uttar Pradesh and adjoining parts can never be compensated in the Peninsular parts.

Research Activities

22.2.4 A good network of research stations has existed in the country for sugarcane. Breeding work has primarily been done at Coimbatore. Some of it has also been done at Hebbal and Pusa. The varieties have been tested for suitability at stations in different parts. Most of the research stations have been having sections representing all the necessary disciplines, but the practical impact of researches has not been adequate to lift the yield standard of the crop in the north. Though sugarcane utilisation in the white sugar industry has been just about half of *gur* and *khandsari*, the emphasis at Coimbatore all along has been to produce varieties suitable for that industry. Research on ratooning has also been carried on from the beginning but no outstanding results have emerged. It is reported that Mauritius takes up to 6 ratoons and Hawaii takes 2 to 3 ratoons, but in all such countries, the ratoons are cultivated with as much care as plant crops. Therefore, they record good yields and produce cane of high quality. Ratooning is necessary to bring down cost of cultivation and, being early, it is this crop which can feed the factories earlier than the main crop. On the plant protection side, breeding efforts for pest and disease control have not met with full success, because the initially created resistance breaks down in course of time. As a result a number of pest-disease complexes have always existed in the field, e.g., borer plus wilt; mealy bug plus wilt; scales plus wilt; scales plus wilt plus red rot; wilt plus red rot; nematode plus wilt. Borers of all the three kinds (viz., root, shoot and stalk) are a common feature in most of the sugarcane fields. Pyrilla is equally a menace.

22.2.5 A few beneficial lines for future research work are indicated below :—

(i) There is one disadvantage at present with regard to tiller production that despite a high number to being with, varieties generally stabilise at only a couple of tillers per shoot by the approach of harvest. Breeding researches have to aim for evolving such varicties which can maintain high tiller number even up to the harvest stage and at the same time can bear high population stress throughout. Recent research efforts in the case of maize and jowar have already yielded favourable results in this regard and many hybrids have come into being which can tolerate higher production stress.

(ii) Varieties have to be bred distinctly for sugar industry, *gur* production and ratooning. There is an inherent conflict of interests between the miller and the farmer in the sugar sector. The farmer tries to produce the maximum tonnage

of cane per unit area because the Government prescribes minimum price for sugarcane on the basis of weight and, therefore, he is prone to get more money if he cultivates a variety which gives him a higher tonnage. There is no regard for the sugar content in the farmers scheme of things, whereas the miller desires to have maximum sugar per tonne of cane. In order to resolve this conflict at the breeder's level, the emphasis should be on breeding such varieties which give the highest percentage of recovery—whether it is for sugar or for *gur*. *Gur* manufacture requires comparatively softer varieties of cane with high sucrose content and early maturity has to be developed so that the cane could be processed right from October onwards up to February. The processing after February becomes difficult because the cultivator is not free thereafter owing to the approaching harvest of *rabi* crops. Higher temperatures of March onwards also do not permit good recovery of *gur*.

Agronomy

(iii) Agronomy has to aim at maximum percentage of germination, least mortality and the maintenance of an optimum plant stand up to the end. Another requirement in agronomy is to develop separate agronomic schedules for the plant crop and the ratoons. In both the cases there is a lot of room to increase yield by adjusting the time of planting and harvest and the manurial and plant protection schedules.

(iv) It is known that the canes, which grow in the north, are thinner and shorter than those of the south. In the case of sugarcane, the contribution to yield by a shoot is directly related to its height and girth. Therefore, where these two attributes are lacking the remedy lies in increasing the plant population through the use of high seed rate, reducing early mortality and effective gap filling. Agronomic measures are required to be developed for achieving such high crop densities.

Plant Protection

(v) In the field of pests and diseases, efforts have to be continued for introducing genetic resistance and for finding out effective methods of chemical control. Biological con-

trol of pests is comparatively new and experiments have been conducted in India to some extent in this respect too. Biological control of borers through the egg parasite *Trichogramma* is practised to a limited extent in Mandya district of Karnataka. The Cuban larval parasite, *Lixophaoa diatracae* has not given encouraging results so far. An indigenous parasite, *Isotima javensis* has proved effective in controlling top borer in peninsular India. Fungal parasite *Metarrhizium anisopliae* has given fairly good control of pyrilla in nature, so also *Eninvrops melanoleuca* (a *Microlopidopteran*). This is a good line of approach for the future. Suitable parasites which have already proved effective in other parts of the world could be tried and indigenous parasites have also to be searched and examined. Fungi and bacteria offer a promise for control of insect pests and nematodes. *Chemosterilants,* sex *pheromones,* juvenile hormones and genetic manipulations for controlling pests also need to be tried.

Plant physiology

(vi) Concerted efforts are required for developing biochemical techniques for ripening the crop in environments which are not otherwise congenial for proper maturity. This is also likely to play a significant role in raising the yield level in special situations when it is found that a particular crop is not coming to the required level of maturity in a given time.

22.2.6 It is necessary that research activities other than breeding are performed under the aegis of the agricultural universities of the States in order to find effective and quick answers to local problems. Insofar as breeding is concerned, there are two kinds of works in the case of sugarcane. One is the initial crossing work and the other is the subsequent selection work out of the progeny developed from the 'fluff'. For the former, the importance of the Sugarcane Breeding Institute, Coimbatore as an all-India centre has to be continued though University of Agricultural Sciences, Hebbal is equally satisfactory for such type of work in the south, from the climatic point of view. It will be good if this station is also developed as an important breeding centre in order to cater specially to the regional needs of the south so that Coimbatore can devote more time to the pressing problems of the north. Hebbal can do both the kinds of breeding work (viz., hybridisation as well as selections) for the south in close collaboration with Coimbatore. In the north, only the selection work is effectively possible

and for this Indian Institute of Sugarcane Research, Lucknow should serve as the basic central station in complete coordination with Coimbatore.

Developmental Activities

22.2.7 The sugar producing States in the north have all their own Sugarcane Acts to regulate the availability of cane to mills as also the relationship between the miller and the producer. There are sugarcane boards and councils/committees functioning in some of them for this purpose. Cooperatives have an active role to play between the two interests. On the official side, there is a Cane Commissioner under whose control or advice the various quasi-official or official bodies and functionaries work. In Uttar Pradesh, all developmental work as well as liaison between the farmer and the miller lie in the jurisdiction of the Cane Commissioner. In Bihar, cane development is the responsibility of the Director of Agriculture. In some other States, the functions of the Cane Commissioner are performed by the Director of Agriculture. Efforts of the developmental staff have been concentrated largely on the side of procurement of cane for the mills, i.e., regulating the harvest and supply aspects. In this process, actual developmental work relevant to efficient crop production got neglected. As a consequence, despite an official heirarchy of Agricultural Commissioner/Director of Agriculture and Sugarcane Boards etc., no ice has been cut for increasing the general yield level in the north. The situation in the south has been a little better, because the industrialists and departments there have taken relatively more interest than in the north. Some of the sugar factories in Tamil Nadu, Maharashtra and Andhra Pradesh had taken so much interest that they were running their own research farms for testing of varieties and even manuring and cultural practices. At the official level, all kinds of activities relating to sugarcane have been looked after by the Departments of Agriculture.

22.2.8 It has to be recognised at this stage that emphasis on all the developmental work has throughout been in the factory areas where sugarcane is almost exclusively grown for the manufacture of white sugar. In this process, uplift of the other areas, which produce about 75 per cent of sugarcane, has throughout been neglected. Neglect of the developmental work has meant neglect of seed (i.e. planting material), irrigation, manure and plant protection schedules. Seed in circulation is so degenerated and disease-ridden that it acts as the biggest drag on improving production. Multiplication of quality seed has been emphasized in Chapter 47 on Seeds, but its distribution channels also require to be streamlined. In order to rectify existing position in all directions, an integrated all-round approach for

improving sugarcane production in the entire concerned area is called for—whether it is for sugar or *gur* or *khandsari* production. Experience has shown that any bifurcation of responsibilities at governmental level, such as between the Director of Agriculture and Sugarcane Commissioner, has not proved conducive to any material improvement. The extension efforts relating to crop production can never be effective or complete without the involvement of the Department of Agriculture and, therefore, this activity has to come fully within the purview of this Department. All the States, with the exception of Uttar Pradesh, more or less conform to this structure. Uttar Pradesh should also follow the same pattern. The sugarcane production wings of the Departments of Agriculture can in themselves have a cell for promotional activities of vital interest to industry. The *gur* and *khandsari* sector, which has been neglected so far, should be organised by such cells with the same zeal as the sugar sector.

22.2.9 A time has now come when every sugar factory should have a strong cane development wing headed by one Chief Cane Development Officer like the Chief Engineer or Chief Chemist in the factory. The factories have been confining their activities uptil now only to procurement of cane. They have not worried in general for rendering advice to sugarcane growers for efficient production, which could ultimately lead to better outturn per unit area both in terms of total tonnage as well as sugar content. Effective advisory service can pertain to (a) the most beneficial time of planting in a staggered manner so as to continue supplies to enable the factories to run for as long a period as possible, (b) suitable planting method and material, (c) subsequent management of the crop and (d) harvesting programmes with an eye on better yield of sugar per unit area. The factories should have well trained field staff for carrying such developmental functions. The factories should be made responsible for arranging supply and services too. For instance, they can maintain mechanisation units for providing service to farmers in land preparation, pest control measures, etc. Similarly, they can arrange for supply of inputs and even credit. In short, a very close working link between growers and factories has to be developed in all respects. All this has to be made a mandatory function of the factories in order to be effective. Governmental involvement in the 'factory versus grower problems' should be restricted to a minimum; it can be confined to a supervisory role to see that the above mentioned scheme functions effectively and that there is no kind of exploitation of the cane grower. The factories and Governments have to act alike in educating and inducing the farmer to give due regard to quality (i.e. sugar content) besides quantity in his production psychology. The Government of India's

recent measures of fixing the minimum price of cane with additional premium for extra recovery over a certain fixed base is a welcome development. The minimum price was Rs. 8 per quintal of cane linked to a recovery of 8.5 per cent or below with a premium of 9.4 paise for every increase of 0.1 per cent in recovery in 1972-73 and 1973-74; it became Rs. 8.50 per quintal linked to the same recovery percentage but with a premium of 10 paise for every increase of 0.1 per cent in recovery in 1974-75. This measure is expected to go a long way in making the grower fully quality conscious in the days to come. The farmer does not, at present, distinguish between cane for sugar and cane for *gur* in factory area. He grows the factory variety and changes to *gur* when the price for *gur* is high. The factories and Governments are required to educate the farmer in this regard too.

22.2.10 The impact of all the improvement measures suggested above—research, organisational and developmental—will certainly be such as to improve the yield levels throughout the country. There is undoubtedly more scope in this respect in the north than in the south. It will be easy approximately to double the yield standard in the north by 2000 AD; the value could be fixed at 75 tonnes/ha. Even in the Peninsular States, it should be possible to raise it by one-third and maintain it at a level of 100 tonnes/ha. Despite the contemplated increases in yield, it will also become necessary to effect area increase in order to meet domestic as well as export demands. For area increase, the south has to get preference due to higher yield potential. From irrigation point of view, the maximum area which can be put under this crop in Peninsula, will be as follows:

	(Mha)
Maharashtra	0.60
Karnataka	0.40
Andhra Pradesh	0.30
Tamil Nadu	0.27
	1.57

For the country as a whole, the sugarcane area in 2000 AD can be kept as 5 Mha, i.e., at twice the existing level. This would mean that the States outside the Peninsula would have to increase the area under the crop by about 1.5 Mha. In the north, Uttar Pradesh and Bihar can still go in for more sugarcane area, but this should be done after determining the capacity of other promising States like Madhya Pradesh Orissa and irrigated parts of Rajasthan.

Sugarbeet

22.2.11 Sugarbeet is really a crop of the temperate regions. According to 1969-70 estimates contained in the FAO Year Book 1970, the world production was 220 million tonnes and out of it other parts like the Near East, China and Japan were responsible for the fraction ranging from 2 to 7 million tonnes only. Pakistan and India are also making endeavours to augment their sugar production through this source, Sugarbeet in India was tried on a very small scale, in the pre-Independence period, first in the North West Frontier Province in 1914 and later at Indore and Pusa. Isolated attempts on sugarbeet cultivation have also been made in Ahmednagar and Padegaon in Maharashtra. The Indian Institute of Sugarcane Research, Lucknow, revived interest in 1959 by planning a limited multilocation testing programme to assess the agricultural feasibility of the crop. The G. B. Pant University of Science and Technology initiated research on sugarbeet in 1964. The Department of Agriculture, Jammu and Kashmir Government also got interested in sugarbeet with a view to exploring the scope for generating a beet-based sugar industry in the State. In the private sector sugarbeet cultivation trials have been carried out by M/s Phaltan Sugar Works, Shakharwadi, Maharashtra, in collaboration with the Nimbkar Agricultural Research Institute, Phaltan. The Tariff Commission Enquiry on cost structure of the sugar industry (1969) has referred to promoting beet cultivation in this country. An All-India Coordinated Research Project on Sugarbeet was started by the ICAR in April, 1970. Eight research centres are participating in the programme. A few universities are also cooperating as voluntary centres. The National Seeds Corporation has created seed production capacities in the Kashmir Valley and Simla Hills. The Tarai Development Corporation has also planned beet seed production.

22.2.12 The Directorate of Sugarcane Development, Government of India, is responsible for developmental activity on sugarbeet. The operational areas have been confined to the two factory zones, viz., Sriganganagar (Rajasthan) and Phaltan (Maharashtra), where sugarbeet is processed on a semi-commercial scale. The farmers are supplied sugarbeet seed free of cost and they are given the assistance of development staff for technical advice. The Rajasthan State Department of Agriculture, in addition, has laid out demonstrations in Sriganganagar area in farmers' plots in order to educate and enthuse them. It is understood that a modest financial support to Nimbkar Institute of Agricultural Research, Phaltan for the sugarbeet programme is being provided by a firm in Bombay. The Government of Jammu and Kashmir has launched a modest beet cultivation programme in farmers' fields through

cash incentives and a beet sugar plant is being contemplated for this State. The Centrally sponsored sugarbeet programme is proposed to be extended to 23 sugar factories in Punjab, Haryana and Uttar Pradesh during the Fifth Plan period. The targetted sugarbeet area by the end of the Fifth Plan in these factory zones is expected to be around 50,000 ha. The temptation to go in for this crop really arises from two facts, viz., (a) that the crushing season can be extended upto May with the advantage of better recoveries from it in this period, because recovery from cane then dwindles and (b) that sugar production programme could be extended to cool hilly regions like Himachal Pradesh and Kashmir, where sugarcane does not thrive. There are practical limitations to both these propositions. It is not easy to provide irrigation to additional area in the months of March to May and water needs of sugarbeet are none too modest, rather these almost equal the irrigation levels recommended for sugarcane with the added disadvantage that it is much more susceptible to water deficiencies than sugarcane. In the hills, there is the limitation of area and the choice of crops needed to be grown for regional prosperity is large. Owing to these limitations, the maximum area that can be allocated to this crop may not exceed half-a-million hectares and the parts which seem best suited for maximum extension are Jammu & Kashmir, Himachal Pradesh, west Uttar Pradesh hills and plains, Punjab, Haryana and Rajasthan. Assuming an yield of 40 tonnes/ha and a recovery of 10 per cent the contribution of sugarbeet can be reckoned at 2 million tonnes of sugar. The crop will require full backing of irrigation.

Palms

22.2.13 There are three palms which are utilised in India for the preparation of *gur* or crystal sugar, viz., *Phoenix sp.* (date), *Borassus sp.* (palmyrah) and *Cocos sp.* (coconut) and out of these the use of first two is more common. Date palm abounds in the northern and central parts mostly growing wild on waste lands. Palmyrah is prolific in the eastern and southern parts. To have an approximate idea of relative performance, 50 trees of palmyrah can be taken to yield one tonne of sugar per year, whereas for the same quantity, the number of date palms will be about just the double. Palms have usually attracted attention of common people as a source of toddy and as long as the emphasis was on toddy, no one seriously thought of tapping them for *gur* or sugar. It was only after 'prohibition' that Khadi and Village Industries Commission tried to give an organised shape in some places to gur production. Palm gur represents a minor cottage industry at present. Systematic production figures are not available. West Bengal,

Andhra Pradesh and Tamil Nadu may be producing palm gur to an extent of 7-8 thousand tonnes per year each. Orissa's production may be between 1 and 2 thousand tonnes. In many other States like Punjab, Uttar Pradesh, Madhya Pradesh and Karnataka the production is only nominal, say, of the order of 20-30 tonnes. The overall production is not expected to be more than 50,000 tonnes. It may not exceed 100,000 tonnes per year even after fullest exploitation and, therefore, is not of consequence from all-India angle. It requires continued attention, which is expected to be bestowed upon it by the concerned States in the usual course.

Sorghum

22.2.14 *Andropogon sorghum* variety *Sacchartus,* is used as a source of sugar in some countries. The presence of starch has been an obstacle in its large scale exploitation but technological processes like *enzymic* conversion, *flocculation* and *aglutination* are now known which can overcome it. One of the highest yielding varieties, Rio can produce on an average about 25 tonnes/ha of stalks containing about 10 per cent sugar. The grain from sweet sorghums is not usually acceptable as human food. The heads, leaves and the stem can all be used directly as cattle feed or ensilaged. Sweet sorghum occupies about 7 per cent of the crop area in the USA. This crop was introduced there to develop subsidiary sugar industry, but now it is mostly used for silage making. Sorghums by nature are grown mostly rainfed and occupy the field for about 120 to 150 days. Herein lies the attraction towards sweet sorghum in this country as a source of sugar in contrast to sugarcane, which requires irrigation and engages the field much longer. The Sugarcane Research Institute, Lucknow and Nimbkar Agricultural Institute, Phaltan (Maharashtra) have conducted some experiments on this crop recently. However, there are two factors which have to be fully weighed before embarking on any large scale programme. These are mentioned below :

(i) Main jowar growing belt comprises Maharashtra, Karnataka and their adjoining areas. In these parts, jowar constitutes a staple food and the area, which has been put in the estimates, is just sufficient for grain purposes. It is difficult to increase the area under this crop to any significant extent to make a perceptible contribution to sugar industry.

(ii) The yield of stalks is one-third or even less than what can be obtained from sugarcane in those parts.

Notwithstanding the above mentioned drawbacks, experimental endeavours can still be watched and encouraged, but it is not possible

to take cognisance of the contribution from this source in national planning at this stage.

3 TOBACCO

22.3.1 Tobacco occupies a place next only to mineral oils in terms of the quantum of revenue collection through excise duty on raw material and cigarettes which was of the order of Rs. 300 crores in 1971-72. The per capita annual consumption of tobacco goods in India is a little less than a kg when compared with 2-4 kg in other countries. However, the commodity is not, something which needs popularisation out of the way. All the same, the country has to be ready to meet the demands of its population as these develop in natural course. The trend in the past was in favour of chewing, *hookah* and *chelum* but it is changing now in favour of cigarettes and *bidis* (Appendix 22.3—Statement I). *Hookah* and *chelums* had contrivances to filter the smoke and though filter tips are being increasingly used now in cigarettes, there is no such thing yet in sight for *bidis*. In the case of *bidis*, smoking hazards may become less with the availability of varieties having less nicotine content. Besides the tobacco leaves required in the manufacture of cigarettes and *bidis*, the other essential requirement is that of wrapping material. Cigarettes are wrapped in paper, cigars in outer tobacco leaves of suitable quality and *bidis* in the leaves of certain selected trees. The paper industry of the country is competent enough to meet the needs of special kind of covering paper. There is scarcity of filter rods, which may also be attended to in due course. Anyhow, these aspects are being attended to by the paper and tobacco manufacturing industry. As *bidi* wrapper involves a natural product, it has been considered by us in Chapter 43 on Minor Forest Produce.

22.3.2 The main emphasis in India could be on export and other industrial and germicidal uses of tobacco. The country already exports about 15 per cent of its production in the form of unmanufactured tobacco, mostly fluecured Virginia (VFC). India's share in international trade is around 12 per cent, ranking second, next to the USA. The commodity mostly goes to UK and USSR. In our Interim Report on 'Certain Important Aspects of Selected Export Oriented Agricultural Commodities' we have laid emphasis on exploring other markets too. It has been stated therein that special efforts should be made to increase production of low nicotine VFC as well as oriental tobaccos, which were much in demand in the East European markets. There was need for rationalising the cost structure of tobacco culti-

vation in order to encourage the export of inferior and filler types of tobacco, for which there was a good demand outside. It was felt necessary that the new varieties, whenever evolved by research institutes, should be released for commercial cultivation only after those had passed manufacturing tests conducted by the cigarette industry. This was necessary because tobacco companies felt that the laboratory tests regarding leaf quality in themselves did not prove adequate to determine its manufacturing suitability. Extension agencies were required to concentrate their attention only on the varieties thus approved.

22.3.3 Country's overall position with regard to area and production in the last 30 years, as reflected by the 5-year averages, is presented in Appendix 22.3—Statement II. The statistics have been given for (a) Virginia separately, (b) tobaccos other than Virginia and (c) all combined.

The following facts are brought out by this table :

(i) The area under tobaccos other than Virginia has not shown any marked change on the whole. It has just varied around a central figure of 300 thousand hectares.

(ii) If the area increase has taken place significantly, it is in the case of Virginia. The area has more than trebled itself in the last thirty years or so. It stands around 150,000 ha at present and is half of what is under all other kinds of tobacco.

(iii) The yield level has not shown any marked change. In overall assessment it has been fluctuating between 0.7 and 0.9 tonnes/ha. Between 1950 and 1960, the average for all tobacco was 0.7 tonnes/ha, whereas between 1960 and 1970, it was 0.8 tonnes/ha.

(iv) In the case of Virginia, no such consistent tendency is noticeable. It is more a case of variation around 0.7 tonnes/ha than any trend. Therefore, if at all there is any perceptible sign of increase, it is in other tobaccos rather than Virginia.

22.3.4 Tobacco crop of commercial importance belongs to two species of genus *Nicotiana* of *solanaceae* family, *viz., Nicotiana tabacum* and *Nicotiana rustica. Tabacum* has tall plants with long broad leaves and usually pink flowers. *Rustica* has short plants with round puckered leaves and yellow flowers. Specific varieties in *tabacum* have been developed for cigarette, cigar and cheroot, *bidi, hookah,* chewing and snuff. The varieties developed in *rustica,* are used mainly for *hookah,* chewing and snuff. *Nicotiana rustica* plays a relatively minor role in the present world tobacco economy. Area and production statistics are at present published by the Directorate of Economics and

statistics, Ministry of Agriculture and Irrigation, for *rustica* and *tabacum*. Under the latter species, the statistics are reported separately for Virginia and others. The average percentages of area and production under each species are given below on the basis of the data for 1965-66 to 1971-72 :

	Area per cent of total	Production per cent of total
Nicotiana rustica	7.5	7.8
Nicotiana tabacum	92.5	92.2
(i) Virginia	33.8	29.7
(ii) others	58.7	62.5

22.3.5 Variety-wise and usagewise statistics are not available at present. It is learnt that the matter was once taken up with State Governments, but many of them had expressed difficulty. However, a fair amount of idea with regard to the production trends, usagewise, can be had on the basis of clearance granted to unmanufactured tobacco on payment of duty for the production of various tobacco products, the data relating to which are maintained by the Directorate of Statistics and Intelligence, Central Excise and Customs, New Delhi and published in their Statistical Year Books. The items included are cigarettes; cigar and cheroots; *bidis*, chewing, snuff and *hookah* tobaccos, stalks, others, destruction or agricultural purposes (duty free); and quantity allowed as personal consumption to curers. A snag in this compilation is that some part of the production which passes illicitly as non-duty paid tobacco has to be excluded from consideration. It will be good if the Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation and the Central Customs and Excise Department could collaborate with each other and determine how best varietywise and usagewise statistics could be collected and reported at one place in a uniform way.

22.3.6 Statewise area and production statistics of 'all tobacco' are given in Appendix 22.3—Statement III. The following facts are worth noticing :

(i) All States grow tobacco, but the area and production in Gujarat and the peninsular States put together are 83-84 per cent of all-India, of which the three States of Gujarat, Andhra Pradesh and Karnataka account for 76 per cent and of these, Andhra Pradesh alone is responsible for 48 per cent of area and 45 per cent of production.

(ii) Northern States account for 16-17 per cent of area and

production. Uttar Pradesh, Bihar, Orissa and West Bengal are prominent amongst these.

(iii) The crop is taken unirrigated in the main area, which grows it extensively, viz., Andhra Pradesh, as also in Maharashtra and Karnataka. It is taken with irrigation in Gujarat, Tamil Nadu and majority of the northern States.

(iv) Yields are the highest in Gujarat and Tamil Nadu (1—1.5 tonnes/ha) while in north yields are generally between 0.7 and 0.9 tonnes/ha. The yield in Andhra Pradesh is of the order of 0.8 and that in Maharashtra and Karnataka only of the order of 0.5 tonnes/ha.

22.3.7 The commercial cultivation of tobacco is concentrated in certain well-defined areas. The following 21 districts taken together account for about 80 per cent of the total tobacco area :

State	District	State	District
Andhra Pradesh	Prakasam Guntur	Tamil Nadu	Coimbatore
	Krishna East Godavari West Godavari	Maharashtra	Kolhapur Sangli
	Nellore Kurnool Khammam	Bihar	Muzaffarpur Darbhanga Purnea
Gujarat	Kaira Baroda	Uttar Pradesh	Farrukhabad
Karnataka	Belgaum Mysore	West Bengal	Cooch-Behar Jalpaiguri

There is the following type of broad specialization of tobacco growing among States from the viewpoint of usage :

(i) Andhra Pradesh is the premier Virginia growing State. According to the data for three years ending 1971-72, the distribution of area under Virginia is : Andhra Pradesh 97.5, Karnataka 2.3 and Maharashtra 0.2 per cent. Besides Virginia, Andhra Pradesh produces sun-cured country or *Natu* tobacco (which is also used in the manufacture of cigarettes and tobacco mixtures for pipe), white Burley used in the manufacture of cigarettes and *Lanka* tobacco used in the manufacture of cheroots.

(ii) The cultivation of *bidi* tobacco is concentrated in Charotar area of Gujarat and Nipani area covering Belgaum district in Karnataka and Kolhapur and Sangli districts in Maharashtra. Thus, Gujarat, Karnataka and Maharashtra are the important *bidi* tobacco producing States in India.

(iii) *Vilayati, Motihari* and *Jutty* types of *hookah* tobacco are cultivated in Muzaffarpur, Darbhanga and Purnea districts in Bihar and Cooch-Behar and Jalpaiguri districts in West Bengal. These types of tobacco are also used for chewing and snuff manufacturing purposes. Farrukhabad in Uttar Pradesh is also an important area growing tobacco used mainly for *hookah* and chewing purposes.

(iv) The south Tamil Nadu areas covering Madurai and Coimbatore districts grow chewing, snuff, filler and binder tobaccos for cigar and cheroots.

22.3.8 Virginia tobacco has received the best of attention, because it had to feed cigarette industry in Britain as well as the developing cigarette industry in India. The erstwhile Imperial Tobacco Company of India Ltd., along with its sister concern Messrs Indian Leaf Tobacco Development Company Ltd. (ILTDC), had introduced Virginia cultivation in India around 1923. The ILTDC found locations in Andhra Pradesh and concentrated attention there. Other tobaccos, which were not needed in European markets, were not attended to as much as Virginia and this has continued to be the picture in nutshell even todate. The interest of Messrs ILTDC made them establish their own research station at Rajahmundry. They have continued their involvement in research and development throughout. The Government of India has also been interested in the crop due to revenue earnings. It passed a Tobacco Excise Act in 1943. This act was later merged with the consolidated Central Excise and Salt Act of 1944 and the proceeds rapidly led to the establishment of the Indian Central Tobacco Committee (ICTC). The Government also introduced compulsory grading of tobacco meant for export just about that time (1945-46). Tobacco is graded and marked in accordance with the standards laid down in the Tobacco Grading and Marking Rules (1937) framed under the provisions of the Agricultural Produce (Grading and Marking) Act, 1937 and is certified to that effect by the Agricultural Marketing Adviser, Ministry of Agriculture and Irrigation, Government of India. The quantity of tobacco graded for export purposes has been increasing since then and currently it is of the order of about 60 thousand tonnes per annum. The quantity which circulates within the country is not graded rigidly. A Tobacco Export Promotion Council was established in January, 1956. The Council is an association of exporters and advises the Government with regard to development of India's exports of tobacco and tobacco products. With a view to obviate unhealthy competition among the export trade, the Government of India introduced in 1963 a system of fixing maximum and minimum export prices for the various grades of Virginia and other types of tobacco

meant for export. Accordingly, the Tobacco Export Promotion Council issues Price Certificates on tobacco meant for export. Since 1965, the system of fixing ceiling prices for tobacco has been stopped. At present, there is only minimum export price for certain grades of VFC, Virginia sun cured, sun-cured *Natu* and sun-cured *Jutty* tobaccos. The Tobacco Export Promotion Council functions under the Ministry of Foreign Trade, Government of India.

22.3.9 Most of the VFC varieties grown in the country are introduction from either the USA or other cigarette tobacco growing countries. Whatever yield the introduced varieties could give under Indian conditions seems to have been more or less accepted and emphasis in the country's research work was placed on maintaining their quality. Quality oriented research work has found precedence over other factors owing to the kind of tobacco preferred for cigarette manufacture—whether meant for export or internal utilisation. Production was essentially increased by expanding area rather than through improvement in yield per plant or per unit area. In latest times, the emphasis is on expanding tobacco area in light soils, because it has been shown that VFC tobacco produced on such soils possesses properties like fluffiness, higher filling value and low nicotine content. A Centrally sponsored scheme to replace tobacco cultivation from black cotton soil, wherever possible, and/or to extend it to new light soil areas was initiated in 1966-67 with the cooperation of the State Governments and till 1971-72 an area of 22,309 ha was covered (Andhra Pradesh 18.4, Karnataka 2.3, Gujarat 1.4, Tamil Nadu 0.1 and Uttar Pradesh 0.1 thousand ha). Surveys recently conducted indicate a potential of 40 thousand ha in Karnataka. Similar potential for extending light soil tobacco cultivation to more than 100,000 ha are estimated to be available in Nellore, West Godavari and Prakasam (Ongole) districts of Andhra Pradesh. Besides, suitable soil and climatic conditions are also available in Hosur area of Tamil Nadu, Saharanpur district in Uttar Pradesh and Vijapur area of Mehsana district in Gujarat for growing this VFC tobacco. Growing of tobacco on lighter soils, however, involves resort to irrigation, whereas the crop on heavy black cotton soils is mostly taken rainfed because of the advantage of its moisture retention capacity. As another example of area change may be cited the recommendation of the *Ad hoc* Committee on Tobacco (Patel Committee) set up in 1964 by the Ministry of Commerce, Government of India, whereby the growing of tobacco on saline and other undesirable lands was required to be stopped even if it meant legislation, because it was found that tobacco produced on saline soils (chlorides being more than 0.01 per cent), low lying areas and tank beds became hygroscopic and did not burn and it also lost colour in storage. Such

tobacco growing areas in Andhra Pradesh total up to 20,000 ha and are concentrated in two taluks, viz., Bapatla and Ongole.

22.3.10 Quality work relating to Virginia leaf is narrated in the following few examples :

(i) Detailed investigations on the objective assessment of quality resulted in arriving at certain chemical ratios such as Schmuk Number, Kovalenko Coefficient and reducing sugars/nicotine as reliable yardsticks for measurement of smoking quality.

(ii) Physical quality characters, which determine the manufacturing economy, are found to be associated with filling value, porosity equilibrium, moisture content, leaf strength, leaf-elasticity and shatterability.

(iii) The method for chemical examination of leaves to distinguish "saline tobacco" for the purpose of Agmarking was evolved and this method has been adopted by the Directorate of Marketing & Inspection for estimating the chlorides in tobacco intended for export.

(iv) Poor burning quality of leaf due to excessive chlorine can be corrected to some extent by the application of potassium.

(v) Tobacco when graded as per plant position gives a more clear-cut differentiation between the grades on the basis of chemical composition and quality ratios than the grades based on visual characteristics like colour and blemish, which are currently adopted in Agmark specifications. Leaf nicotine decreases from bottom to middle positions and then again there is an increase. Sugar-nicotine ratio, which is an indication of smoking quality increases to the middle position and then drops perceptibly. Thus, grading procedure can be improved by introducing plant position grading.

(vi) It is better to harvest tobacco at correct maturity. Slight over-maturity is to be preferred to immaturity. A simple test-paper technique for determining the exact maturity status of VFC tobacco has been found.

(vii) Quality of VFC tobacco was found to improve upon ageing. A period of 12 months has been found optimum for ageing.

(viii) Dark green grades which are priced very low could be improved to light medium green grades by heat treatment under humid conditions whereby the value is enhanced six times in terms of price.

(ix) Low nicotine cigarettes could be made from tobaccos treated with hydrogen peroxide since it improves chemcial

oxidation of the alkaloid as well as increase in the specific volume of the tobacco shreds. A few laboratory or in-field methods of estimating nicotine in green leaves have also been attempted.

(x) Quality aspect is reflected even in the pest and disease work. Chemical control in the case of this crop is fraught with the danger of leaving permanent residue on leaves which are known to be harmful in smoking. Therefore, for controlling the major pests that commonly occur on tobacco, recommendations on the use of only approved pesticides have been made. Further, to keep the insecticidal residues within tolerance limits, dosages have been fixed and also time interval between the last spray and harvest determined. Advice to growers not to use chlorinated hydrocarbons for tobacco, e.g. Endrin, DDT, Aldrin, Dieldrin etc., has been properly incorporated in control schedules. Some harmless methods of disease or pest control have also been studied. For example, powdery mildew is controlled by removing lower leaves or by the application of sulphur between the plant rows. The use of *Pongamia* cake (an indigenous product obtained from *Pongamia glabra*) mixed with fine sand at the base of freshly transplanted seedlings is known to control effectively the incidence of ground beetles.

22.3.11 The yield aspects of Virginia have also started coming to the fore in recent times. Through breeding efforts, a few mammoth mutants have already been derived, which have 35 to 40 leaves as against an average of about 20 to 25 in established varieties. However, the number of curable leaves in these mutants is much less than the total. For example, in a mutant name SDMD, the total number of leaves is 43, whereas the curable leaves are only 27. As against this, the reduction in established varieties is only of the order of 2 to 3 leaves. Leaf quality in mutants is also inferior. Further work is in progress at Rajahmundry to remove the defects of these mutants through hybridisation with varieties having other desirable characteristics. Obtaining higher yields through increased plant density has also engaged attention very recently. It has been found possible to increase plant population from the usual level of about 17,000 plants per hectare to 28,000 through adjustment of distance between rows and plants. It was possible to get in this experiment the cured leaf yield of about 2 tonnes per hectare as against 1.3 tonnes in control with variety HR 65-35, which has erect leaf habit. In addition, it is on record that deep ploughing in black cotton soils in summer improves its moisture retention and thus helps to increase the yield of cured leaf by 10—15 per cent.

The Central Tobacco Research Institute at Rajahmundry has also drawn up a package of practices in addition to deep summer ploughing involving tillage in kharif season, use of improved varieties, deep placement of recommended doses of fertilisers, topping and desuckering and recommended plant protection measures, which all go to further enhance the yield. There are some improved package of practices available for use in the *Lanka* soils in Godavari delta. By following this package of practices, it is estimated that the yield can be almost doubled in this area.

22.3.12 The position in regard to *bidi* research work is slightly different. It is important to note that, though the area under this crop has decreased in the States of Gujarat and Maharashtra from 93,000 to 86,000 and 26,000 to 13,200 hectares respectively during the decade ending 1970-71, yet the total production of *bidi* tobacco increased from about 78,000 to 100,000 tonnes in the same period. This is largely due to increase in yield in Gujarat, where research efforts have been successfully geared to increase the per hectare yield potential. Gujarat has realised an increase of 73 per cent in per hectare yield of *bidi* tobacco in the last two decades owing to the use of high yielding varieties, improved cultural practices and controlling pests and diseases. The share of improved varieties is said to be about 44 per cent. Although Maharashtra and Karnataka mainly raise rainfed crops of *bidi* tobacco, yet it should be possible to raise yields there too. *Bidi* tobacco varieties currently under cultivation in these parts are being grown there since long. No outstanding research results on new varieties or other aspects have so far been reported by research workers in that area and, therefore, there is scope for new varieties and practices. Similarly, it should be possible to raise the standard of yields in other parts of the country by identifying the existing causes and removing the same. The impact of research on the qualitative and quantitative improvement of *hookah*, chewing and snuff types of tobacco has been considerably limited.

22.3.13 Research work in the direction of finding high yielding varieties or hybrids and new agronomic techniques, as reflected in the recent attempts with mutants and spacing trials, requires to be given more and more importance in order to improve yields per plant as well as per unit area of land. The attempts have to be multidirectional including breeding, agronomy and plant protection. It is necessary that due emphasis is given in future research work to all kinds of tobacco (usagewise i.e. whether meant for cigarette, *bidi*, *hookah*, chewing or snuff). Research work is also required to be planned for evolving varietal and agronomic practices for air-cured tobacco, such as Burley, *Natu* etc. These tobaccos can be developed with advantage for export purposes. Fluffy, air-cured tobaccos with low tar and nicotine are pre-

sently in demand and since their use in cigarette manufacture is on the increase, demand for these types of tobacco is likely to go up. *Natu* and *Lanka* tobaccos are known to be aromatic in nature and, therefore, these are likely to be preferred for blending in cigarette manufacture. Their cost of production is low. Hence, exploring the possibilities of utilising these is a worthwhile direction for research. With the switch over to light soils, irrigation may become an increasing necessity. Reduction of chloride content or prevention of deterioration in quality due to irrigation will, therefore, assume importance in future. Insofar as plant protection is concerned, biological control of pests has to be tried for this crop, because this will completely cut across the need for tackling the problem of pesticide residue.

22.3.14 Future researches will also have to be geared to producing tobacco with less tar, nicotine or other carcinogenic substances. The Central Tobacco Research Institute, Rajahmundry, has drawn up a research programme to be taken up on priority basis during the Fifth Plan period on the following lines :

(i) possibility of adopting suitable cultural and manurial practices, varieties and postcuring processes, which hold promise in reducing the carcinogenic substances in tobacco smoke,

(ii) identification of varieties and types of Indian tobacco exhibiting less carcinogenic properties,

(iii) methods to reduce carcinogenic properties through tobacco selection (varieties, types, blending, mixing etc.), chemical additions (oxidants etc.) and physical processing techniques, and

(iv) post ageing operations which include steaming for various periods, addition of humectants and flavouring agents and blending with different grades and types with a view to evaluate the smoke characteristics.

Besides, continuous quality surveillance for timely detection of pesticide residues beyond tolerance limits is also proposed to be undertaken by the Institute. A Pesticide Residue Analysis Unit has been established there recently. The studies are at present confined to VFC tobacco, but these are proposed to be extended to other types also. While all these steps are in right direction, it is necessary that, in addition to the Central Tobacco Research Institute, the agricultural universities of the tobacco growing areas are associated in the investigational programmes. It is also necessary in future to introduce compulsory grading of all leaves—whether meant for domestic consumption or for export. It will be good if the scientific method of grading based on the position of leaf over the plant is introduced. Grading according to plant position involves simultaneous harvest of leaves from a particular position all at

one time. This is necessary (a) so that the required quantity of leaf material is obtained for economic functioning of barns and (b) at the same time for ensuring that leaves of different positions do not mix together. Though this is a difficult proposition under Indian conditions because of the scattered nature of tobacco fields and villages, which makes difficult the collection of requisite types, yet this is a problem worthy of attention from the research workers. The problem is how best to make grading economical and yet stick to the scientific method of plant position.

22.3.15 Developmental schemes have been concentrating on extending area or seed production or extension and training programmes. Work relating to area increase has already been considered. Insofar as seed is concerned, a scheme for the production and distribution of pure seed and seedlings of tobacco is in operation since 1956. The scheme is fully financed by the Government of India and is implemented through the Central Tobacco Research Institute, Rajahmundry, the Tobacco Research Stations at Vedasandur, Hunsur, Dinhata and Anand and the Punjab and Haryana Agricultural Universities at Ludhiana and Hissar respectively. The ILTDC also operates a programme of multiplication of pure seeds of cigarette types of tobacco. The company, however, does not have any programme for the multiplication of *bidi* and other types of tobacco seed. The present arrangements are sufficient to meet entire requirement of pure seed and seedlings of tobacco in different parts of the country. The efforts of State Governments in regard to extension and package schemes cover 18 districts. The headquarters of various schemes are located at seven centres, viz., Muzaffarpur (Bihar), Guntur, Eluru (Andhra Pradesh), Anand (Gujarat), Seroncha (Maharashtra), Nipani (Karnataka) and Coimbatore (Tamil Nadu). The districts covered by each centre vary from 2 to 4. Staffing at these centres is said to have been meagre. For instance, in Andhra Pradesh, one graduate tobacco assistant has to look after an average area of about 10,000 ha spread over a number of villages. A package programme for tobacco is in operation in Coimbatore district of Tamil Nadu for chewing tobacco.

22.3.16 Training programmes at present in operation for tobacco may be classified under three categories viz., (a) training of farmers, (b) training of extension officers and staff and (c) training of staff under extension schemes and market committees in Agmark grading. These are briefly described below :

(i) Training of farmers : Training schemes for farmers are in operation at the Institute of Agriculture, Anand and the Tobacco Research Station, Dinhata. The broad objective of these schemes is to impart training to the farmers in

improved methods of tobacco cultivation, handling, curing and marketing. The scheme at Anand was started in 1957 and the duration of the training course is for a period of nine months. The number of participating farmers in each training course is of the order of 25 to 30. At Dinhata, the cultivation of cigar wrapper and filler tobacco has been introduced recently and the training there is meant to familiarise farmers in the cultivation of cigar tobacco. Such a training course was started in 1964-65. The duration of the course is for nine months and about 20 candidates undergo training every year. Besides these training programmes, the Directorate of Extension have facilities to give training to tobacco farmers in their Farmers' Training Centres at Kudige and Hallikere in Karnataka. Camps for the training of farmers in improved methods of cultivation are also held in Andhra Pradesh and Karnataka during the tobacco season. This activity forms a part of the Centrally sponsored scheme for exportable types of tobacco.

(ii) Training of Extension Officers and staff : At present the officers and staff are sent for training to the training school run by ILTDC at Hunsur. The duration of this training course is six months. The stations at Anand and Dinhata also impart training to staff under extension schemes besides their training programmes meant for farmers.

(iii) Training of Staff under Extension Schemes and Marketing Committees in Agmark Grading : Grading of tobacco as per Agmark specifications is compulsory for tobacco marked for export. As Virginia tobacco is an export-oriented crop, more than half of its production is graded as per Agmark grades. The Directorate of Marketing and Inspection runs a training course at Guntur (Andhra Pradesh) for training of officers and staff belonging to State Governments and cooperatives in Agmark grading of VFC tobacco.

22.3.17 The general structure of developmental activities relating to this crop covers all necessary spheres. What is needed is to invigorate the activities in all the important tobacco growing districts without exception. These activities should cover all kinds of tobaccos in their areas of production. Staffing in every district should be in consonance with the workload involved. It is necessary that the Ministry of Agriculture and Irrigation should review the entire structure with the concerned State Governments. With all possible research and developmental measures and the above mentioned possibilities, it should be possible to

raise the yield of the crop substantially. Brazil, Italy, Rhodesia and Thailand record yields between 1 and 1.7 tonnes/ha. Canada, USA and Japan even go to an extent of 2—2.5 tonnes/ha[1]. Keeping in view the yield levels in other countries, our yield target for 2,000 AD may be fixed at 1.5 tonnes/ha. It is a little difficult to foresee the trends for a narcotic like this ; even then a margin of increase by about 100,000 ha in area can be contemplated to be on safer side. The average area between 1969-70 and 1971-72 being 450,000 ha, the area in 2,000 AD would be 550,000 ha giving an outturn of 825,000 tonnes.

4 COTTON

22.4.1 The Indian textile industry, which depends upon cotton, constitutes the largest single industrial segment in the country in terms of annual value of output and labour employed both direct and indirect. There were 672 cotton textile mills in India in 1972 having an installed capacity of 18.15 million spindles and 208,000 looms. The industry provides direct employment to nearly 900,000 workers and indirect employment to several million. The decentralised sector comprising power looms, hand looms etc., is reported to provide employment to over 2.5 million people. Fears are now expressed that the importance of cotton crop might get reduced in future due to competition from man-made fibres. It may be noted in this connection that pure synthetic fabrics are uncomfortable in summer due to low ventilation and moisture absorption capacity resulting in increasing apparel temperature and blocking of perspiration. These fabrics also have the undesirable property of generating static electricity, which gets more pronounced in winters. Therefore, what will be more common in a country like India is the blend of polyester etc. with cotton and this should be a welcome development because it will decrease domestic demand for cotton and to that extent it would become more available for export purposes to other tropical and sub-tropical countries. Besides lint, cotton seed is already being used in the manufacture of hydrogenated oil and this is going to be more so in future. When cotton seed is diverted for crushing on a large scale, the cake, which will still be a rich concentrate, will serve as a good livestock feed. Thus there is no reason to view with anxiety the prospects of this crop.

22.4.2 The area and production statistics used in this section relate to years 1968-69 to 1970-71. It will become clear as one proceeds with the current discussion that examination of Relative Yield Index

1 F.A.O. Production Yearbook, 1970.

TABLE 22.2

Area under Cotton, Chief Cultivating Districts, Yield and Extent of Irrigation (1968-69—1970-71)

States	Area (thousand ha)	Area (% of all-India)	Districts (a)	Yield of lint kg/ha	RYI (b)	Irrigation (c)	Districts with percentage of irrigated area (d)							
							less than 1%	1-9.9 %	10-14.9 %	15-24.9 %	25-49.9 %	50-89.9 %	90-100 %	Total
Punjab	397	5	6	357	305	97							6	6
Haryana	200	3	4	308	263	99							4	4
Rajasthan	241	3	7	130	111	71	2					4	1	7
Uttar Pradesh	51	1	1	153	131	90							1	1
Madhya Pradesh	688	9	12	76	65	1	7	5						12
Gujarat	1,613	21	17	169	144	17		6	1	4	6			17
Maharashtra	2,778	36	16	66	56	2	8	6		1		1		16
Karnataka	1,020	13	8	61	53	3	5	2	1					8
Andhra Pradesh	316	4	5	53	45	3	4				1			5
Tamil Nadu	313	4	4	192	164	22			1	2		1		4
other States	31	1												
all-India	7,648	100	80	117	100	16	26	19	3	7	7	6	12	80

(a) Only such districts are mentioned which have 10,000 ha or more per district under cotton.

(b) RYI—Relative Yield Index as used in this table is the State yield express as % of all-India yield.

(c) Irrigation cotton area as % of total cotton area in State (1969-70)

(d) Irrigated cotton area as % of total cotton area in district (extracted from Appendix 22.4—Statement I).

TABLE 22.3

Area under Cotton, Irrigation and Distribution of Chief Cultivating Districts* under Different Rainfall and Yield Ranges (1968-69—1970-71)

State	Total area under cotton ('000 ha)	Percent irrigated area 1969-70	RYI[a]	Number of districts in rainfall types										
				A4/ A3	A2	A1	B2	B1	C4/ C3	C2	C1	D4/ D3	D2	D1
Madhya Pradesh . .	688	1.3	(less than 90)		3	2	5	2						
			(more „ 90)		1									
Maharashtra . . .	2,778	2.3	(less „ 90)		1	2	2	8	1					
			(more „ 90)							(1)	(1)			
Karnataka . . .	1,020	2.6	(less „ 90)					1.5	2	1.5	3			
			(more „ 90)											
Andhra Pradesh . .	316	2.8	(less „ 90)			1			1		2			
			(more „ 90)						(10)					
total . . .	4,802[b]													
Gujarat	1,613	16.8	(less than 90)					(1)						
			(more „ 90)	1	1	5	1	6			2			
Tamil Nadu . . .	313	22.3	(less „ 90)									(1)	(1)	
			(more „ 90)									1	1	1
total . . .	1,926[c]													

Punjab	397	97.1	(less than 90)											
			(more ,, 90)						3	3				
Haryana	200	98.5	(less ,, 90)					1	1					
			(more ,, 90)					1	1	2				
Rajasthan	241	71.2	(less ,, 90)		(1)		(1)							
			(more ,, 90)			2	1			1			1	
Uttar Pradesh . .	51	90.4	(less ,, 90)											
			(more ,, 90)						1					
total	889[d]													
other States . . .	31													
all-India total . . .	7,648	15.7		1	6	12	10	19.5	10	8.5	8	1	3	1=80
area in different rainfall types as % of all-India . .				0.2	3	16	10	37	7	10	9	1	3	1

Note.—*The districts considered here are those which have an area of 10,000 hectares or more.

(a)=Yields expressed as % of all-India yield. All-India average yield of cotton (1968-69 to 1970-71)=117 kg/ha.

(b)=63% of all-India area, (c)=25% of all-India area, (d)=11.7% of all-India area.

(c)=Figures within brackets show exceptions to the usual order.

(RYI) has been made in a more detailed manner for this crop as compared with others. The RYI data being available for 1968-69—1970-71, the same period has been chosen for other data also. Basic information pertaining to area, yield, main cotton growing districts, RYI and irrigation is presented in Table 22.2. The main conclusions emerging from this table are stated below :

(i) Major cotton area lies in the States of Gujarat and Maharashtra, which in themselves account for 57 per cent of all-India area. The adjoining States of Madhya Pradesh and Karnataka and another 22 per cent to area, taking the overall total of all the 4 States to about 80 per cent of all-India.

(ii) Cotton area in the States of Punjab, Haryana and Rajasthan in the north and Andhra Pradesh and Tamil Nadu in the south is in the range of 3—5 per cent each.

(iii) Except for Gujarat, the yields are poor in the main cotton region comprising of Madhya Pradesh, Maharashtra and Karnataka and also the adjoining State of Andhra Pradesh (RYI=45 to 65).

(iv) Except for Gujarat, above average yields come from the States which are not important from the area point of view viz., Punjab, Haryana, Rajasthan, Uttar Pradesh and Tamil Nadu. Punjab and Haryana RYI is of the order of 300. In others, it ranges from 111 to 164.

(v) Fortyfive districts, i.e., nearly half of the total have less than 10 per cent cotton area under irrigation. Eighteen districts have irrigated area of 50 per cent or more and out of these, 16 are in the northwest.

22.4.3 The yield aspect has been studied in detail in relation to rainfall and existing irrigation facilities. The study has been made for all the 80 cotton growing districts of India which have 10,000 ha or more under this crop. Total cotton area in such 80 districts is 7.4 Mha, i.e., nearly 97 per cent of the overall all-India area and, therefore, the study is representative of almost the entire cotton area. Rainfall patterns for each of the 80 cotton growing districts under examination are given in Appendix 22.4—Statement I together with information on irrigated area and RYI. A statement of RYI in two categories, i.e., lower and greater than 90 for different States falling in different categories of rainfall has been extracted from the Appendix and is presented in Table 22.3. There are the following two broad conclusions emerging from this table :

(i) Nearly 60 per cent of districts with 66 per cent of area lie between the higher rainfall types A2 to B1. This class includes the main cotton growing areas in the States

of Gujarat, Madhya Pradesh and Maharashtra. The performance of the crop is not uniform.

(ii) Another 33 per cent of districts with 26 per cent of area lie in C type rainfall. The performance of the crop is good wherever irrigation has been resorted to. Major area of the northwestern parts of the country falls in this type. Most cotton areas of Karnataka and Andhra Pradesh also fall in this class.

22.4.4 An examination of the main cotton growing areas of Gujarat, Madhya Pradesh and Maharashtra is now taken up. A reference to Table 22.2 would show that (a) all the cotton growing districts in Madhya Pradesh have less than 10 per cent of cotton area under irrigation, (b) in Maharashtra 14 out of a total of 16 districts have less than 10 per cent of cotton area under irrigation and (c) in Gujarat, 6 districts have less than 10 per cent irrigated area, 1 between 10 and 15 per cent, 4 between 15 and 25 per cent and 6 between 25 and 50 per cent. This position in Gujarat refers to 1969-70; the number of districts in different ranges of irrigated area in that State in 1968-69 was 6, 5, 3 and 3 respectively. The number and names of districts with less than 10 per cent of irrigated area in Gujarat in both the years are the same. Really speaking, less than 10 per cent irrigated area can hardly influence the overall performance of a crop in a given State. For this reason, a contrast has been made between Gujarat and other two States only with respect to such districts which have less than 10 per cent cotton area under irrigation. A frequency distribution of districts of these States with less than 10 per cent irrigated area lying between A and B types of rainfall and having different RYI is presented in Table 22.4. But for one exception in B1C1D2 (Surendranagar), where the RYI is less, Gujarat records good yield throughout (RYI = 115 to 160). In the case of Madhya Pradesh and Maharashtra, most of the districts record low yields (RYI = less than 70). Insufficiency of irrigation does not seem to be the whole answer of this low performance.

22.4.5 A2 to B2 conditions imply in general a rainfall distribution of not less than 20-30 cm per month atleast in two months, the months invariably being July and August. B1 implies one month with 20-30 cm; it may be either July or August. The remaining monsoon months have a rainfall of less than 20 cm. Rainfall is never evenly distributed in time; there are a few spells of heavy rainfall every year and the chances for such falls are more in A and B than in lower categories. High soil moisture at seedling stage is detrimental to growth. An initial growth occurs in the months of July and August and as these are the very months when there are occasions of high rainfall, there are chances of the crop suffering from such situations to some

extent. Secondly, high soil moisture even after the seedlings stage can still prove harmful for the crop by encouraging more vegetative growth and because vegetative growth is inversely related to the fruiting capability, the crop yield ultimately suffers. There are many agronomic practices prevalent in Gujarat, e.g., (a) taking the crop on ridges, (b) dibbling and (c) gap filling. Ridging leads to better drainage conditions in a field. Dibbling of a number of seeds ensures the ultimate survival of at least one seedling per spot. The practice of gap filling, if resorted to meticulously and watchfully, can ensure an optimum plant population. Gujarat farmers are said to grow even a row of paddy in between cotton rows in some heavy rainfall areas. It seems as if Gujarat has specialised in devising better means of drainage and agronomy and, therefore, its success stems from better water management practices designed to suit the excess rainfall conditions.

TABLE 22.4

Relation between Rainfall Pattern and Yield of Cotton in some Districts of Gujarat, Madhya Pradesh and Maharashtra, which have less than 10 per cent of their Cotton Area under Irrigation.

Rainfall pattern	Number of districts in each range of RYI (=District yield as per cent of All-India yield)						
	Gujarat		Madhya Pradesh			Maharashtra	
	70-90	greater than 110	less than 50	50-70	70-90	less than 50	50-70
A3B1		1		1			
A2B2							1
A2B1C1		1	1	1	1	1	
A2C2				1		1	
A1B1C2		2		1	1	1	1
A1B1C1D1				4			2
B2C2				4			2
B2C1D1				1			
B2D2							
B1C3				1	1	2	6
B1C2D1							
B1C1D2	1	1					
class total	1	5	1	9	2	3	10
State total	6		12			13(a)	

(a) The other districts with less than 10% irrigated area are in lower rainfall category.

22.4.6 If the rainfall patterns given in Appendix 22.3—Statement I are examined in detail, it will be found that the months of September and October have rainfall mostly of less than 20 cm per month. For a crop sown towards the end of June or beginning of July, this will be the period during which will fall the tail end of vegetative phase and the commencement of flowering phase. Therefore, spells of less rainfall in those months can hamper growth and lead to dropping of 'squares' or reduced 'bearing'. In some parts of Gujarat, the practice of dry sowing late in May or early in June is resorted to. This practice gives the advantage of ready utilisation of the first rainfall itself better than when preparatory steps to sow the crop are commenced with the actual onset of rains. Moreover, clean cultivation and deep soils can also be responsible for the maintenance of steady moisture supply. This once again is a case of better management practice. While examining the performance of Gujarat, Madhya Pradesh and Maharashtra in the light of rainfall and irrigation, it must be said that, judged by the performance of Gujarat, there is no reason to assume that rainfall is inadequate for the successful raising of cotton crop in Madhya Pradesh or Maharashtra. The degree of success seems to depend upon the efficiency of water management and attuning the crop to rainfall rhythm. It is an interesting case for study by the experts of Madhya Pradesh and Maharashtra both from the agricultural universities and Departments of Agriculture, in cooperation with those of Gujarat. The districts where rainfall conditions can be said to be decidedly insufficient for this crop are Aurangabad (Maharashtra) ; Belgaum, Gulbarga, Dharwar (part), Bijapur, Raichur, Bellary, Chitradurga (Karnataka) ; Mahboobnagar, Kurnool and Anantapur (Andhra Pradesh). Rainfall is of C4/C3, C2 or C1 categories in the monsoon season and E4 or D1E3 in post-monsoon months. There is no meaning in taking cotton in these districts unless irrigation water can be assured.

22.4.7 We have given due consideration to rainfed versus irrigated cultivation of cotton. There can be the following four possibilities in this regard :

(i) Irrigation resorted to during the entire life span of the crop. Even during rainy season, the crop will have to be irrigated during spells of drought, e.g., Punjab, Haryana, etc.

(ii) Fully rainfed, as practised at present in Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and parts of Gujarat also.

(iii) Irrigated in pre-monsoon months and then rainfed during monsoon and post-monsoon periods. Practised to some extent in Gujarat.

(iv) Rainfed to begin with and irrigated in post-monsoon period according to need, e.g., Tamil Nadu.

The possibilities (i), (iii) and (iv) have to be broadly classified under 'irrigated category' from an Irrigation Engineer's point of view, because these involve dependence upon some irrigation at one time or the other.

22.4.8 Insofar as the fully rainfed crop is concerned, a note has to be taken of the following three possibilities :

(i) If the crop could be started early in May and irrigation could be provided to it in May and June, rainfall of the further period is sufficient to carry through the crop.

(ii) Next best will be to 'dry-sow' the crop early in June so that it gets the best advantage of the starting rains. This will suit areas where monsoon breaks by the 2nd or 3rd week of June. This may in itself carry through the crop or one or two irrigations may become necessary towards the end. This possibility requires experimentation before adoption on a large scale.

(iii) The third possibility is to continue to sow the crop in July and arrange for irrigation during stress periods wherever necessary. In A2 to B1 areas (specially up to B2) there will be occasions when rainfall may be heavy over short spells in the months of July and August. If this could be harvested through farm pond technique, it would have two advantages, viz., (a) to some extent, it will save the crop from waterlogging and (b) the excess water duly stored can itself be used to provide irrigation to the crop in the months of September and October.

If advantage is taken of all the three possibilities in future years judiciously according to local circumstances, there is no doubt that the performance of the crop can be improved to best possible standards even in Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh.

22.4.9 Demand for cotton is going to be such that area increase to maximum possible extent is inescapable. Bearing in mind the future irrigation potential and capacity of different States for expansion, a projection for increase in area has been drawn up in Table 22.5. It could be seen that the total area under cotton is proposed to be increased by about 4 Mha and irrigation has been increased from the present level of 16 per cent to 65 per cent of the area. The increases in cotton area are generally in the range of 0.2 to 0.4 Mha per State, except for Uttar Pradesh, where about 0.8 Mha have been allotted, as the western districts of this State can give as good a performance as Punjab and Haryana. Under the head 'Other States" in Table 22.5 there is

provision for new promising areas like the Sunderbans of West Bengal or paddy fallows in the State where cotton cultivation can be possibly undertaken during the period December—April. Such areas in Andhra Pradesh and Tamil Nadu are already attracting attention and similar areas in eastern Bihar, Orissa and West Bengal are also worth a trial.

TABLE 22.5

Area under Cotton as Projected in 2000 AD

(million hectares)

	Present area	Proposed area in 2000 AD			
		Irrigated	Rainfed	Total	Increase
Punjab	0.4	0.7	..	0.7	0.3
Haryana	0 2	0.5	..	0.5	0 3
Rajasthan	0.2	0.4	..	0.4	0.2
Uttar Pradesh	0.05	0.8	..	0.8	0.75
Gujarat	1.6	0.9	1.1	2.0	0.4
Madhya Pradesh	0.7	0.3	0.6	0.9	0.2
Maharashtra	2.8	1.4	1.8	3.2	0.4
Karnataka	1.0	1.0	0.3	1.3	0.3
Andhra Pradesh	0.3	0.5	0.1	0.6	0.3
Tamil Nadu	0.3	0.5	0.1	0.6	0.3
other States	0.03	0.5	..	0.5	0.47
total	7.6	7.5	4.0	11.5	3.9

22.4.10 Although other scientific steps and increasing use of inputs will surely help to better the yield standards, irrigation as a single factor will also prove effective in this regard. It is relevant to recall that the average yield of lint per hectare in undivided India was 73 kg in 1931-32[1]. It increased to 110 kg by 1941-42[2] probably because of the contribution of Sind and West Punjab in the cultivation of American cottons under irrigation. Then came the partition and consequent loss of these fertile cotton growing parts. As a result, the yield level in post-partition India got reduced to 86 kg/ha in 1947-48[3]. It has been gradually lifted upwards since then. Although the yield of a single recent year, viz., 1971-72 has touched 151 kg/ha mark, the average of the three years ending 1970-71 has been only of the order of 120 kg/ha. The main drag to the country's overall performance has stemmed from the huge area in and around the Deccan whose yields have been of a low order of just about 60 kg/ha. This position is likely to change with our suggestions relating to water

1 Estimates of Area and Yield of Principal Crops in India, No. 37, 1934-35, Department of Commercial Intelligence and Statistics, India.

2 Estimates of Area and Yield of Principal Crops in India, No. 44, 1941-42, 1942-43 and 1943-44, 44th issue, Department of Commercial Intelligence and Statistics, India.

3 Estimates of Area and Production of Principal Crops in India, Vol II, 1952-53, Directorate of Economics and Statistics, Ministry of Food and Agriculture.

management and crop adjustment. When this happens, cotton yield in this country should compare favourably with those of any other part of the world. Yield position of some cotton producing countries of the world is given below :

Country	Average yield in kilogram/hectare (1965-66 to 1969-70)
USA	539
USSR	809
UAR	676
Sudan	410
Syria	549
Mexico	699
Peru	534
Brazil	247
China	293
Pakistan	290
India	133
world average	345

22.4.11 Three standards for yield could be considered for 2000 AD. These are 500, 400 and 300 kg/ha. The first one is kept for the States of Punjab and Haryana, where cotton is grown only under irrigation. Their yields are already between 300 and 360 kg/ha. Therefore, the proposed rate should be deemed to be achievable by 2000 AD. The second rate is kept for other irrigated areas. The third rate is kept for rainfed areas. Gujarat has already recorded an average of 170 kg/ha in the third category. Therefore, raising it to 300 kg/ha in the next 25 years should not be an impossibility. Even better standards are possible to be achieved with concerted efforts, specially in irrigated areas and then the above prescribed standards might appear moderate. Yields as high as 800 kg/ha have been reported from Karnataka in Tungabhadra project area. An alternative set of standards can be 600 for Punjab and Haryana, 500 for other irrigated areas and 350 for the rainfed areas. Calculations of production according to both sets of targeted yields are given below :

Parts	Area (Mha)	Yield (kg/ha)		Production (million tonnes)	
		Alternatives			
		I	II	I	II
Punjab and Haryana	1.2	500	600	0.60	0.72
other irrigated parts	6.3	400	500	2.52	3.15
improved rainfed parts	4.0	300	350	1.20	1.40
all-India	11.5	376	458	4.32	5.27

22.4.12 Cotton had received a set-back during the Second World War when legislative and executive curbs were clamped on its growing because of emphasis on Grow More Food campaign. Special Cotton Extension scheme had to be launched in 1950-51 to offset this effect. Incentives and facilities were provided to farmers for raising cotton under these schemes, which were continued during the First and Second Plan periods. Major emphasis in these plans was on effecting increase in cotton area. It was from about 1962-63 onwards that package programmes were initiated in all the major cotton growing States with the financial support of the Government of India with a view to give pointed attention to effect improvement in yields. Package programmes financed from the resources of the State Governments or Centre cover at present about 750,000 hectares. An Intensive Cotton District Programme was sanctioned to cover 580,000 hectares between 1971-72 and 1973-74 in irrigated areas and 140,000 hectares in the rainfed areas. As an example of extension of cotton to new areas, a mention is made here of the Sundarbans belt. Presently, it is mono-cropped with paddy from June to November and the land remains fallow thereafter. Trials have revealed the possibility of taking a cotton crop between December and May with the available soil moisture which is surcharged during the periods of high tides. A Centrally sponsored scheme is in operation there for cotton development work and due to efforts made under it, about 4,690 hectares have been grown with cotton during 1972-73. However, drainage is found to be a serious problem along the coast and nearby islands. A crash programme to provide cross drains in compact blocks covering 2 to 4 thousand hectares has been launched there for this purpose. The extent of area covered in all such programme is but a small fraction of the total area and, therefore, its impact on increasing all-India production has been limited. As the area under cotton is going to increase substantially in future, this problem of coverage with better programmes will become further acute unless attended to with added fervour.

22.4.13 Research work on cotton in recent times can be said to have started with the establishment of Departments of Agriculture from the beginning of this century. In the report on the Progress of Agriculture in India for 1907—1909, it was stated that the distribution of seeds of selected pickings from cultivators fields had been in progress for more than four years in several provinces. In 1908, eight cotton seed farms were maintained by private agencies under a guarantee from Government against losses. The object even then was to establish a number of such farms independent of the Government but receiving its assistance when required for the provision of seed

and trained staff for advice. Thereafter the work went on in different States in pursuance of this object. The emphasis was on propagating the seed of new varieties as much as possible. The trials conducted during that period led to the establishment of *hirsutum* cotton in two pockets in India—one around Gadag in Karnataka and the other around Lyallpur in the then Punjab. The improved varieties obtained from these parts were known for a long time as Gadag American and Punjab American. The Indian Central Cotton Committee (ICCC) also realised the importance of the supply of seed of established improved varieties of cotton being made readily and cheaply available to cultivators and invited in July 1929 the State Governments to submit proposals based on local requirements. The ICCC had sanctioned in all 80 seed multiplication and distribution schemes up to 1960. Prior to 1958, seed multiplication and distribution work was done under two schemes—one under the extension scheme sanctioned directly by the Government of India and the other by the ICCC and the State Governments. Thereafter the two were amalgamated under one charge.

22.4.14 Cotton research was accelerated with the inception of the First Five Year Plan in 1951. Breeding of new varieties is a continuous process and improved strains evolved in the earlier years were progressively replaced by still superior varieties. In the recent past, viz., during 1968—72, 15 new varieties of cotton have been released for cultivation. Varieties *Sujata, Suvin* and MCU 5 are examples of extra long staple cotton. Suvin, a cross between Sujata of Egyptian stock and the Sea Island cotton of St. Vincent variety, is the longest staple cotton (34 mm or 1.35 inches) so far released in India with a spin of 120 counts or more. Hybrid-4 and Varalaxmi are examples of long staple hybrids. Hybrid-4 has been developed at Surat and extended for cultivation during the past three years. It is an intra-*hirsutum* hybrid. (Gujarat 67 × American Nectariless). It is said that breeding nectariless varieties might help in reducing menace of such insects which are attracted because of the presence of nectar in flowers. Hybrid-4 is the first successful attempt in this direction. Varalaxmi is an interspecific hybrid between *hirsutum* and *barbendense* (Laxmi × SB 289 E). It has been developed at Dharwar. It is better than Hybrid-4 in spinning quality. It is suited to irrigated areas of Karnataka and other States. Breeding work of this kind has made it possible to replace gradually the Asiatic cottons (*Gossypium arboreum* and *G. herbaceum*) with American uplands (*G. hirsutum*). A couple of thousand hectares are also now put under *G. barbendense,* but this area is negligible in terms of all-India area. An idea of this change can be had from Table 22.6. Spread of

hirsutum has been mostly at the cost of *arboreum*. The species *arboreum* is a low yielder and had been common in Madhya Pradesh, Maharashtra and Andhra Pradesh. Even now it occupies about 30 per cent of all-India cotton area in these parts. The use of *herbaceum* varieties has comparatively persisted all along. This species is still favoured in Gujarat and Karnataka. It is late but yields heavy and performs better under dry conditions.

TABLE 22.6

Percentage of Total Area under Different Species of Cotton
(1938-39 to 1969-70)

	Years				
	1938-39	1947-48	1955-56	1960-61	1969-70
G. herbaceum . .	34	32	26	26	21
G. arboreum . . .	64	65	54	45	29
G. hirsutum . . .	2	3	20	29	50
total area Mha . .	8.07	4.32	8.08	7.68	7.71

22.4.15 The present position of production of cotton of different staple lengths based on the data of 1968-69 to 1970-71 is indicated in Table 22.7 :

TABLE 22.7

Production of Cotton Staple Lengthwise*
(1968-69 to 1970-71)

Kind of cotton	Production	
	(tonnes)	% of all-India
superior long staple (27 mm and above)	26,640	3.0
long staple (24.5 mm to 26 mm)	209,340	23.4
superior medium staple (22 mm to 24 mm)	410,220	45.8
medium staple (20 mm to 21 mm)	127,620	14.2
short staple (19 mm and below)	122,040	13.6
total	895,860	100.0

*Based on Table 3, Bulletin of Cotton, Jan-Feb. 1973, Directorate of Cotton Development, Bombay.

This table further confirms that the emphasis has all along been on cultivating the exotic cottons of superior quality. The coarse cottons figure only to an extent of about 30 per cent in the overall production, because the trend in the consumption patterns within the country is now in favour of superior quality. Despite this, the Government of India have recently announced a new textile policy calling upon the industry to double the production of controlled varieties of cloth, which are manufactured from medium staple cottons. The excise duty on fine yarn and cloth has been recently increased, which has made the mills to go in for production of coarser yarn and cloth. On the other hand, there is a new thinking in important circles that it is advantageous for the country in several respects to use more of long staple cotton and push up the average count of yarn produced by the industry. If this view is accepted and the excise duties are suitably restructured, there is bound to be a steep increase in the consumption of long staple cottons. The overall export market is also in favour of long staple and superior medium staple cottons. These cottons are produced by other countries also, e.g., Egypt, Sudan and the USA, but the production in India has the capacity to face competition. As against this, it is also a fact that the other countries do not produce coarse cottons and if India gears up its production programme relating to them, she will have to face much less competition. Coarse cottons of medium and short staple lengths will remain in demand in many of the developing countries and this can prove to be to India's advantage. In the light of the factors discussed above, it is a little difficult at present to fix any rigid proportion for the production of different kinds of cottons for 2000 AD. It will be prudent to make a periodical review, say after every five years, of the demands both for domestic purposes and export and then gear the production programmes accordingly. However, it should be quite on cards to be prepared for an increased production of coarse cottons of medium and short staple lengths. It is possible to develop high yielding hybrids for these cottons also and, therefore, it will be in the fitness of things if their improvement through appropriate breeding method is also kept in view. The Cotton Development Directorate, Bombay has already thought of giving a boost to these cottons in the Fifth Plan period.

22.4.16 Although there has been considerable improvement from quality point of view, one cannot escape from noticing that the yields have not shown material improvement in parts that matter for cotton production. Research efforts in this regard should, however, not be totally denied. Studies on fertiliser levels, spacing and plant population ; soil versus foliar application of nutrients, time and method of

application of fertiliser, mixed or inter-cropping trials, etc., have resulted in drawing up appropriate agronomic schedules for different parts. Experiments on spray fertilisation of urea have shown that it is possible to increase yield of cotton appreciably in rainfed areas. Trials conducted with the growth retardant chemical Cycocel as a foliar spray have proved that there is distinct scope for increasing yield in certain varieties without any adverse effect on fibre quality. Most results on intercropping show that this does not suit cotton crop. Intercropping with legumes like groundnut, greengram, soyabean and blackgram is being practised in many rainfed areas. In Madhya Pradesh, Maharashtra and Gujarat, cotton is sown mixed with groundnut, soyabean, in 2 : 1 or 2 : 2 ratios. Pigeonpea and jowar or maize are also sown often after every 6—10 rows of cotton. Recent studies on keeping the plant population of cotton optimum and squeezing some rows of groundnut or soyabean within cotton rows by spacing adjustment have shown reduction in cotton yield to the extent of 20—25 per cent. In Karnataka, intercropping of cotton with groudnut, *setaria,* wheat, soyabean, linseed and cowpea has shown more reduction in yield with *setaria,* wheat, linseed than with groundnut. On plant protection side, despite continued efforts in the direction of breeding varieties for field tolerance to jassids and bollworms and resistance to wilt, root rot and bacterial blight etc., these pests and diseases do continue to take toll of the crop. Experiments have been going on in various centres on chemical control of pests and diseases and, as a result, some useful plant protection schedules have emerged for different parts.

22.4.17 In short, there is no dearth of results and we are confident that problems as and when they arise will always get due attention. What is needed immediately is that, in general, the results of practical utility should be shifted regionwise and these be fitted into suitable agronomic and plant protection schedules. Keeping the future yield targets in view the regions could be formed by combining the States in the following manner :

(i) Punjab, Haryana, Rajasthan and Uttar Pradesh;
(ii) West Bengal, Bihar and Orissa;
(iii) Gujarat, Madhya Pradesh and Maharashtra;
(iv) Karnataka, Andhra Pradesh and Tamil Nadu.

These groups are made only for the main areas. It does not preclude other States from making their own efforts. In fact, we are in favour of all States, including those mentioned above tackling their own problems—research by their agricultural universities and development by their agricultural departments. The groups only indicate that, in addition to individual efforts, the States of each group can profitably

join together to face and solve common problems. Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh require the best of attention both from their own States as well as from the Centre and of these Maharashtra needs prime attention because of its major share of involvement in cotton crop. The Central Cotton Research Institute at Nagpur has already come into being. This is quite in fitness with our thinking. Regional stations at Hanumangarh (Rajasthan), Baroda (Gujarat) and Coimbatore (Tamil Nadu); which will function as sub-stations to the Central Institute, are also contemplated. We do not agree to the creation of a few sub-stations as sub-centres. We are of the opinion that the Central Institute should instead develop a working partnership for the regional problems with the agricultural university of every State.

22.4.18 Some suggestions are now made for future research work, which will also help in realising the yield targets. An indication of agronomic adjustments required to be made in order to make the best possible use of the rainfall patterns has already been given in some previous paragraphs. Adjustment of cropping season so as to take advantage of insect or disease free period is another direction which can prove effective in combating pests and diseases without resorting to chemical methods of control. In the case of potato, harvesting the crop in Uttar Pradesh etc., before December, up to which aphids do not occur in the plains, has resulted in exterminating mosaic in seed potato to an appreciable extent. In the case of cotton too, the differential occurrence of pests and diseases in different periods requires investigation. Gujarat is at present growing *herbaceum* types which mature late. Their flowering and fruiting periods fall in the months of November to January. As against this, Maharashtra and other adjoining States considerably grow *hirsutums*, which flower and fruit from September to November. September to November period represents more humid and less cold period in comparison with November to January period. It is likely that the insect menace is less under November to January conditions. Such an aspect requires study.

21.4.19 Bollworms are a special menace to this crop. Crop protection schedules are available for all the new better yielding and improved varieties of cotton released for general cultivation. When these are adopted individually by cotton growers, it is neither as economic nor effective as it could be when practised on a large scale through some common endeavour. It would confer a great advantage if cooperative pest management practices involving the whole village community can be organised. Biological control of pests assumes significance in the context of shortage of chemical pesticides. Therefore, whereas immediate practical endeavour should be to make the

best use of available chemicals, future research programmes have to lay emphasis on integrated methods of control including biological means.

22.4.20 Heavy rainfall ordinarily causes damage to cotton crop in early vegetation phase. Such a danger will always exist in parts of Gujarat, Madhya Pradesh, Maharashtra and Karnataka. Sea Island cotton, a native of the West Indies, had caught attention in this context as early as 1830. Incidentally, it happened to be one of the world's finest cotton, some of the leading varieties spinning as high as 120s. The ICCC launched a scheme for development of Sea Island cotton in Kerala and Karnataka in 1957-58. The variety chosen for development was Andrews, stapling 1¼" and capable of spinning 70s counts. The attempts were directed to grow it as a rainfed crop under high rainfall conditions, but the crop did not catch up significantly. Later on, attention was concentrated on developing this cotton under irrigation. A centrally sponsored scheme was launched in 1966-67 to develop it under irrigated conditions in Andhra Pradesh and Karnataka. It was also considered in the Deccan Canal Area in Maharashtra and the well irrigated areas of Gujarat. It gave an encouraging performance in these areas. Success under irrigated conditions proves that the Sea Island cotton does require assured and adequate water supply and yet if it did not catch up in the high rainfall areas, it should have been due to the risk of uneven distribution of rainfall which is inherent in our kind of monsoon pattern. This kind of difficulty can be overcome either by adjusting the cropping season or by breeding special varieties, which will fit into the type of rainfall distribution which is met in the high rainfall areas. Early sowings in order to make the plants capable of withstanding heavy amounts of rainfall in the months of July and August are also worth a trial. We have already drawn attention towards this while making a contrast between Gujarat and Maharashtra etc. We have also drawn attention there to some of the other beneficial agronomic practices. In essence, therefore, the problem pertaining to the high rainfall areas reduces itself to the breeding of suitable varieties or developing appropriate agronomic practices. Plant protection schedules will also have to be considered alongside.

22.4.21 Development of cotton not only in Sunderbans but also in other parts of West Bengal or adjoining States is beset with a number of problems, which need to be solved. Firstly, the variety has to be short in duration, as the time available for cotton cultivation is only about 5 months between December and April (thunderstorm activity becomes pronounced in May-June). Although such varieties introduced from other States are now being grown, it would be desirable to develop varieties specially meant for the

tract. Secondly, considerable experimentation is required on agronomic aspects so as to determine the optimal period of sowing, spacing and other cultural practices for maximising the yield levels. Thirdly, the pest problem has to be tackled effectively for evolving proper schedules with minimum cost, as the yields are not high in the tract. Every new area, where cotton cultivation is to be introduced in future, will have some such typical problems which will be required to be tackled according to need.

22.4.22 There are a few problems from technological point of view which will also need attention in future researches. These are stated below :

(i) Breeding of varieties free from gossypol is necessary because we envisage maximum possible use of cotton seed for crushing in order to meet future needs of edible oil. In this connection, it may also be worthwhile to examine whether the oil content in cotton seed could be increased without detriment to the quality or quantity of lint. Hybrid-4 has a high percentage of fat (22) and yet its lint yield or quality is good. However, no generalisation is possible at this stage and further experimentation is necessary.

(ii) Most of the cottons that are currently used by the textile industry for blending with polyester are the imported Egyptian and Sudanese varieties. However, with the evolution of superior long staple cottons in India like *Suvin, Sujata* and MCU 5, work carried out at the Cotton Technological Research Laboratory (CTRL), Matunga, has revealed that some of the superior Indian cottons are quite suitable for blending with synthetics and, when produced in sufficient quantity, can replace imported long staple cottons. Secondly, it may not be necessary to use only extra long staple cottons for blending, because even long staple cottons like MCU4, Hybrid-4, Varalakshmi may prove suitable for the coarse and medium count ranges. Hence, it is necessary that the CTRL should examine the various varieties of cottons continuously both for their individual spinnability as well as their compatibility for blending with synthetics.

(iii) It is well known that, when cotton fabrics are subjected to chemical treatments like resin finishing for improved easy-care characteristics, there is an accompanying drop in tensile strength and other properties. This necessitates the use of very superior cottons initially or the use of blends with synthetic

fabrics. Recent work at the CTRL has, however, shown that there are certain varieties which are more suitable for such chemical treatments by having reduced losses of strength on finishing compared with other varieties. Thus, screening of different varieties of cottons for their suitability for easy-care treatments and identifying them would help the breeder to isolate the causes of such behaviour and help to increase the production of these types of cottons, which in turn will help the industry and consumers.

(iv) In order to understand the factors influencing fibre quality, it is essential to carry out basic research work on the fine structure of fibres. Although cotton fibre has been under study for a long time, still there is no precise information on the relationship between various properties and structure parameters of the fibre. A study is, therefore, needed of the fine structure parameters like fibrillar orientation, degree of crystallinity, crystallite size and so on. Optical and mechanical properties of the fibre also require to be studied.

5 BAST FIBRE CROPS

22.5.1 It is proposed to consider under this group, fibres (a) which are contained in the inner bast tissue or bark of the stem and (b) which are obtained from the fibro-vascular system of the leaves. The first category represents the 'soft' and the other 'hard' fibres. The bast fibres known in India are mentioned below:

Popular name	Generic name	Family
Category (a)		
(i) jute	*Corchorus* sp.	*Tiliaceae*
(ii) mesta	*Hibiscus* sp.	*Malvaceae*
(iii) ramie	*Boehmeria* sp.	*Urticaceae*
(iv) sannhemp	*Crotalaria* sp.	*Leguminosae*
(v) flax	*Linum* sp.	*Linaceae*
Category (b)		
(vi) agave	*Agave* sp.	*Agavaceae*

Jute goods are by far the most popular internally as well as from export point of view and earn maximum foreign exchange for the country. The earnings were about Rs. 200 crores in 1969-70 and 1970-71 and 266 crores in 1971-72.[1] Although the list of end-uses is fairly long, packaging materials constitute at present a major share of entire jute goods market. Flooring and furnishing materials come next. Jute cloth is considered best as backing material for tufted carpets. Jute hessian is also used as an underlay of linoleum. Handloom union fabrics with one yarn of jute and the other of cotton, rayon or any other fibre are gaining popularity for curtains and furnishing fabrics. Woollenised jute fibre is used in making various kinds of cheap woollen fabrics, blankets and wrappers. Such goods are comparable in warmth to woollen goods. These have consumer's preference because of low cost. Table 22.8 dealing with exports of jute goods reveals that, while sacking and hessian goods are showing a declining trend, it is only the carpet backing material which is still holding the field:

TABLE 22.8

Export of Jute Goods

(thousand tonnes)

Year	Sacking	Hessian	Carpet backing	Others	Total
1967-68	156.5	385.0	149.2	60.7	751.4
1968-69	82.7	311.2	197.6	57.6	649.1
1969-70	54.5	261.3	203.3	46.6	565.7
1970-71	85.7	268.2	152.9	51.2	558.0

22.5.2 Mesta has many uses in common with jute. It is used in admixture with jute to the extent of 40—60 per cent in the manufacture of hessian and sacks. It also serves the local needs of farmers with respect to ropes and strings and nets in producing areas. Ramie plant has been grown to a little extent in some parts of West Bengal and Assam. The crude fibre obtained by hand stripping and scraping is not generally marketed but used for making strong ropes, fishing nets and lines for domestic use. Ramie fibre is known as 'steel wire' among plant fibres because of its strength. Its 'ultimate fibre' is very long averaging 10—15 cm. The comparative lengths of other fibres being: cotton 1.3—6.4, flax 3.2, sannhemp 0.8 and jute 0.2 cm. The fibre is creamy to creamy brown after decortication

1 Sham Lal (1973), Times of India Directory & Year book, The Times of India Press, Bombay.

and silky white after degumming. It takes dye easily and its strength, durability, absorbancy and lustre make it a very useful fibre for the manufacture of a wide variety of textile and cordage products. It is about two to three times coarser than cotton, but it is felt that it can be cottonised and spun on standard cotton machinery very satisfactorily. It can be put to use in the manufacture of canvas, tarpaulins, tents, belting, fire-hose, fishing nets, mosquito nets, gas mantles, sewing and shoe threads and upholstery. Army uniforms, camouflage nettings, marine packing, cartridge cloths etc. are some of the products that may be made from ramie for defence uses. Being highly cellulosic, it is fit for making high grade papers.

22.5.3 Uses of other fibres are summarised below :

(i) The principal outlet for agave fibre is in the manufacture of marine and industrial ropes, agricultural and commercial twines and various other forms of cordage and cables. Considerable quantities are also utilised for padding upholstery and matting. Another outlet includes the manufacture of bags and sacks. Sufficient quantities of fibre are used in the weaving of braid, sausage casings, carpets, fishing nets and other types of nets, hammocks, rugs and various types of brushes and brooms. A new recent usage of agave has been as a reinforcement in the manufacture of flat and corrugated polyester sheets, which are said to be stronger and cheaper than the comparable sheets of other materials and these have satisfactory weathering and fire resistance qualities. The first prototype building to be constructed using corrugated sisal reinforced polyester as roofing materials has been built as Arket, near Amsterdam (a cattle shed). Another recent use of agave fibre has been in the construction of tarmac roads, wherein also it has been used as a reinforcing agent.

(ii) Sannhemp fibre is used for a variety of purposes after being made into ropes, strings and twines. Loose sannhemp fibre is used as medium for oiling the axles of country carts. This fibre is also utilised for making fishing nets, floor mattings (*tat pattis*). Some quantity of sannhemp fibre is reported to be mixed with wool at Panipat for the manufacture of carpet-yarns and with jute for making gunny bags. Recently, sannhemp has gained additional importance because of its increasing demand, particularly of the white grades, for the manufacture of cigarette, tissue and security papers. Uses of sannhemp fibre are also reported for making oakum,

rug-warps, linoleum backing, hat braid, fire-hose, bed and table linens, canvas, shoe soles etc.

(iii) First grades of flax yield lines fabrics, while the coarser ones are used for twines, canvas bags etc. The tow is used for articles such as towels, which do not require high quality yarn and it is also used for making cigarette paper. Flax fibre is not produced within the country to any significant extent. The Defence Department and textile industries need some quantity of flax, all of which is at present imported from the UAR and West European countries. The size of import is not precisely known. It was reported to be 515 tonnes in 1970-71 in the Report of the Study Group set up by Ministry of Agriculture for the formulation of Fifth Five Year Plan proposals on jute.

22.5.4 Keeping in view the above mentioned various uses, one has to define very clearly the role of bast fibres before any strategy for their future production can be drawn up. Ramie and flax have some definite possibilities for the future specially in regard to blending with various kinds of textiles. Agave and sannhemp will continue to be required mainly for cordage. Sannhemp is showing promise in the manufacture of special kinds of paper products including currency paper. Insofar as the main use of jute and its close associates, viz., mesta and sannhemp, in packing materials is concerned, the picture is fast changing. Development of methods of bulk storage is reducing their use. The use of paper and synthetic materials like polypropylene, polythene and high density polyethylene has already made considerable inroads into the traditional demand of jute goods in most of the developed countries and there is a growing tendency to go in for synthetics at the cost of jute even internally, because these are light, clean and inert to microbial and chemical actions. In respect of carpet backing, the Indian jute industry, however, still holds a predominant position, though threat to this item of export from synthetics is no less serious. The FAO estimates for 1969 indicate a penetration of some 40 per cent synthetics in the UK and the USA and around 30 per cent in other major carpet producing countries of Western Europe. In secondary backing however, the prospect appears to continue to be somewhat more favourable to jute. On the whole, the Indian Jute Mills Association as well as the Jute Commissioner, Ministry of Commerce (Foreign Trade), feel that the export performance of jute goods will decline rather than improve with time.

22.5.5 Despite the above forebodings, jute and allied fibres have some points in favour too. The appeal for jute goods mainly lies

in their cheapness. Jute products are exceptionally strong and dimensionally stable. These can be pitched, dragged, grabbed at will or stacked up roof-high without slippage, re-used several times, wetted and dried with comparatively small loss in strength. Dents made in jute cloth close up quickly and it takes markings easily. Synthetic materials may compete with jute in cheapness. Because of this reason, one has to be alert to maintain this advantage in jute. Reduction in cost of cultivation and processing is already engaging attention in appropriate quarters in the country. Ribboning and decortication have been made possible, because of which the cost and tedium of retting is likely to go down. Besides these basic advantages, jute and allied fibres have potentialities of use in various kinds of textiles, flooring and construction materials, which have to be developed vigorously. Woollenised jute and allied fibres are already in use in the preparation of sweaters, socks, shawls and blankets. However, these are at present often used clandestinely for woollen goods in the country. Instead, if special attention is paid and definitely improved softer blends could be produced in large quantities, these will have advantage of low cost and, therefore, will be ideally suited for the teeming millions, who cannot afford pure woollen goods in this as well as other developing countries. There does not seem to be room for pessimism when all these possibilities are considered. If cheapness is always ensured, goods made out of jute and other similar fibres will always hold sway in whichever country there is pressure of population. We are inclined to subscribe to this view and accordingly consider these crops.

Jute

22.5.6 Data pertaining to area and yield of jute in the Indian sub-continent since 1936-37 are contained in Appendix 22.5—Statement I. The area and yield in the undivided India were of the order of 1.2 Mha and 1.2 tonnes/ha respectively. The area falling within the Indian Union which grew jute even in the pre-partition days averaged to about 0.3 Mha only. It is common knowledge that this had put the country into great difficulty, because most of the jute mills happened to be on this side of the country and the little area which came to its share was not sufficient to feed them. Therefore, topmost priority was given to increasing the area under jute. An interesting coincidence is noticed in the progress of the area since 1951-52, viz., that the 1st year of every Plan has shown a maximum which dwindled thereafter to a lower value by its ending year. The values of area for the 1st year and last year of three Plan periods and

subsequent years are indicated below :

Years	Area under jute (thousand hectares)
(1951-52)	790
(1955-56)	704
(1956-57)	772
(1960-61)	629
(1961-62)	917
(1965-66)	758
(1966-67)	797 (880 in 1967-68)
(1970-71)	749

22.5.7 It is difficult to ascribe any scientific reason to the higher values noticeable in the initial years of different plans, although variations from year to year tend to indicate in general an interplay of weather and other factors including prices. However, the effect of weather could not have been so dominant as other factors, because it will be shown later that rainfall distribution during the growing season is usually adequate. Despite the sudden periodical increases and yearly variations, a modal value of 700 thousand hectares is discernible between 1951-52 and 1960-61 in Appendix 22.5—Statement I. Similarly, another modal value of 800 thousand hectares is discernible between 1961-62 and 1971-72. On this basis, the post-partition years may be grouped into three distinct periods, viz., 1947-48 to 1950-51, 1951-52 to 1960-61 and 1961-62 to 1971-72. The average areas in these periods were 411, 675 and 798 thousand hectares respectively. If yearly variations are examined separately for the latter two periods with their respective averages, it will be found that these were within 10 per cent in 6 out of 10 years from 1951-52 to 1960-61 and 9 out of the 11 years from 1961-62 to 1971-72. Although the occurrence of higher orders of variations is undeniable, yet the larger frequency of small variations within 10 per cent does provide ground to suggest that this feature cannot be taken to be something special with respect to this crop which does not occur in other crops. Insofar as yield is concerned, the averages for different periods are indicated below:

Year	Yield of jute (tonnes per hectare)
1939-40 to 1946-47	0.95
1947-48 to 1950-51	1.09
1951-52 to 1960-61	1.12
1961-62 to 1971-72	1.21

A slow rise of only 0.26 tonne. i.e., about 3 quintals per hectare is noticeable in the averages over a span of about 25 years, which bears

no proportion to the strides made in researches on this crop.

22.5.8 An examination of districtwise area and yield position for the different jute growing States has been made for the years 1969-70 to 1971-72. The period usually considered for such a study in other crops has been 1968-69 to 1970-71. In the case of jute, the year 1968-69 was very subnormal. It is for this reason that the subsequent three years have been chosen in this case. A summary of this study is presented in Table 22.9. It may be observed that, although there are in all 79 districts which grow jute to some extent or the other, there are 17 districts which have an area of 10,000 hectares or more per district and which in themselves account for about 91 per cent of the all-India jute area. There are another 16 districts whose area is between 1,000 and 10,000 hectares, but the total all-India area accounted for by them is only 8 per cent. The Statewise distribution of all-India jute area is: West Bengal about 56 per cent, Assam, Meghalaya, Mizoram and Tripura put together about 19 per cent, Bihar about 18 per cent, Orissa 6 per cent and Uttar Pradesh 2 per cent. The all-India yield for 1969-70 to 1971-72 works out to be 1.26 tonnes per hectare and the Relative Yield Index (RYI) in majority of the districts having an area of 1,000 hectares or more is greater than 90. There are only 6 districts where the RYI is 90 or less. These are: Cooch-Behar 90, Balasore 90, West Dinajpur 76, Malda 75, Saharsa 69 and Purnea 63. Therefore, the last 4 districts have yields which can be called as appreciably low.

22.5.9 The performance of jute crop has also been studied in relation to rainfall. The rainfall patterns together with information on area and RYI for the 33 districts, which have an area of 1,000 ha or more per district, under jute are presented in appendix 22.5—Statement II. The sowing of jute crop is spread over many pre-monsoon months, the most frequent months being April and May. As initial growth period takes place before the onset of monsoon, the soil moisture conditions of the pre-monsoon months are considered very crucial for the success of this crop. In order to make examination easier, the rainfall symbols of pre-monsoon months have been arranged in the Appendix in the same order as the months of February to May occur. Such an arrangement of symbols does not necessarily follow for the other months. Insofar as the rainfall of four monsoon months of June to September is concerned, the jute growing districts will be found to be scattered in A4, A3B1, A2B2, A1B3/A1B2C1, B3C1, B2C2/B2C1D1 patterns. The RYI ranges between 60 and 150 amongst all kinds of rainfall patterns without any definite gradation of high and low. 29 cases of RYI out of a total of 33 are 90 and above. The rainfall of the monsoon months appears to be

TABLE 22.9

Jute Growing Districts According to Area and Yield (1969-70 to 1971-72)

State	Area		Number of districts with jute area			Total	District with RYI (a)		
	(thousand ha)	Per cent all-India	Less than 1,000 ha	Less than 10,000 but more than 1,000 ha	10,000 ha or more		90 or less	More than 90	Total
Northeast region (b)	145.9	18.7	1	5	4	10	..	9	9
West Bengal	435.2	55.9	3	2	10	15	3	9	12
Bihar	137.0	17.6	4	3	2	9	2	3	5
Orissa	47.0	6.1	9	3	1	13	1	3	4
Uttar Pradesh	13.4	1.7	29	3	..	32	..	3	3
all-India	778.5	100.0	46	16	17	79	6	27	33(c)
per cent of all-India area covered by districts under different categories of area	..	..	1.0	7.8	91.2	100	..	..	..

(a) RYI = Relative Yield Index denoting the district yield as percentage of all-India yield, the all-India yield being 1.26 tonnes per hectare.

(b) The northeast region includes Assam, Meghalaya, Mizoram and Tripura.

(c) The RYI analysis pertains only to those 33 districts, which have an area of 1,000 hectares or more.

adequate on the whole. However, riverine floods adversely affect the crop in places according to situations. This specially applies to districts like Purnea and Saharsa.

22.5.10 Rainfall patterns of the months of April and May for the 33 jute growing districts have been extracted from Appendix 22.5—Statement II together with corresponding RYI and are presented in Table 22.10 for easy reference. It may be seen that 9 districts of Assam region and 3 districts of Sub-Himalayan West Bengal have rainfall patterns ranging from A2 to C1B1. Of these 12 districts, 9 have C type of rainfall in April, but their position improves in May when 9 receive A type and 3 B type of rainfall. The RYI in all these 12 districts is above 90 (90—100 in three cases and 100—125 in others). The other 21 districts lie in the rainfall patterns of D1C1, E1C1, E1D1, and E2. These patterns are insufficient by themselves to ensure best germination or support best vegetative growth in the initial phase. Jute crop is also not irrigated to any appreciable extent. Only about 5 per cent of total area is irrigated in West Bengal and there are only 4 districts of Hooghly, 24-Parganas, Nadia and Murshidabad where irrigation is resorted to an extent of about 9 per cent. Even this level of irrigation is not consequential from an overall point of view. Thus, there is no doubt that the initial growth of this crop takes place under insufficient soil moisture conditions in these districts. However, the rainfall conditions being favourable during the succeeding monsoon period, the crop usually makes good for the earlier handicap and is in a position to give a fair return.

22.5.11 The handicap of inadequacy of April and May rainfall in majority of the jute growing districts is perpetual and this will always be a permanent drag on all efforts which might be made to make improvements in yield. If rapid strides could not be made in the yield level of this crop, it is because of its predominantly rainfed nature during the months of April and May. The prime necessity, therefore, is to provide assured irrigation to this crop in these months. A target to cover 150,000 hectares of jute area under irrigation in West Bengal has already been laid down for the Fifth Plan period. This is nearly 1/5th of the total jute area of the country and 1/3rd of the area in West Bengal. Even if full jute area is to be put under irrigation, it is not a difficult proposition, because it represents but a nominal fraction of the future potential of gross irrigated area.

22.5.12 Insofar as the poor performance of the crop in the districts of Saharsa, Purnea, West Dinajpur and Malda is concerned, one of the causes is said to be the acidic nature of soil and rectification of this condition through liming is already engaging the attention of the Centre as well as the concerned States. For Saharsa and Purnea, it has already been hinted that riverine floods, which occur year after year in these

TABLE 22.10

The RYI in Relation to the Rainfall of April-May for the Selected Jute Growing Districts

District	Rainfall pattern April-May	RYI
United Mikir & North Cachar Hills	A2	113
Lakhimpur	B1A1	115
Cooch Behar	C1A1	90
Jalpaiguri	,,	97
Goalpara	,,	124
Garo Hills	,,	116
Tripura	,,	110
Kamrup	,,	109
Darrang	,,	119
Sibsagar	B2	114
Darjeeling	C1B1	94
Nowgong	,,	108
24-Parganas	D1C1	126
Hooghly	,,	147
Howrah	,,	144
Balasore	,,	90
Nadia	,,	109
West Dinajpur	E1C1	76
Purnea	,,	63
Malda	,,	75
Midnapore	,,	129
Murshidabad	,,	106
Burdwan	,,	138
Champaran	E1D1	97
Cuttack	,,	108
Keonjhar	,,	98
Puri	,,	101
Saharsa	,,	69
Darbhanga	,,	96
Muzaffarpur	,,	97
Bahraich	E2	113
Kheri	,,	113
Sitapur	,,	113

districts, must also be the cause. To protect crops from such kinds of floods has to be a part of a major strategy in water management which has been emphasised in Chapter 21 on Foodgrain Crops.

22.5.13 The area under jute for 2000 AD can be put at 1 Mha. It just means a nominal increase of about 0.2 Mha over the existing area. It is not difficult to achieve this increase in any of the major jute growing districts and it is said that the three districts of Darrang, Sibsagar and Lakhimpur afford an excellent scope for increase. Even then, we leave the matter of effecting the increase open according to expediency in different jute growing States. We are of the opinion that 0.8 Mha of jute area should be cultivated with assured irrigation, while 0.2 Mha can be kept for situations where there may be no other go but to raise the crop under rainfed conditions. Although thunderstorm activity is conspicuous in the jute growing parts of the Eastern States in the months of April and May, dependability of rainfall earlier than mid-May is less than that of the later period. In order to face this situation, cultivators often resort to dry sowing of the crop. This method just gives one advantage that the seeds are in a position to utilise for germination the very first rains whenever these occur. However, the time of occurrence of meaningful rainfall being unpredictable in April, early sowing does not necessarily confer full advantage of earliness to the crop. In view of this, it should not make much material difference if the sowings for this crop are commenced from May rather than April. Sowings in May, on the other hand, will confer one advantage that the crop will have to face less variability in rainfall after mid-May for germination and initial growth. This proposition was discussed with officials of the West Bengal Government but they did not view it with favour. Having to their views, it is proposed that 0.1 Mha can be continued to be grown rainfed according to existing time of sowing, whereas the new time of sowing commencing late from May can be tried in the remaining 0.1 Mha. If this method is not found to give any additional benefit in practice, it can be discarded in course of time. However, a trial seems to be necessary to begin with and there does not seem to be any difficulty to make it a success provided early maturing varieties are specifically chosen for May sowings.

22.5.14 There is adequate information available through research work which could be made use of in effecting improvement in yields. Jute has two species, *viz.*, *Corchorus capsularis* yielding 'white jute' of commerce and *C. olitorius* giving *'tossa'* jute. Researches done under the erstwhile Indian Central Jute Committee (ICJC) and ICAR have much improved upon the standard provided by the earlier prevalent varieties D154 and Chinsurah Green, which were evolved as early as 1918 and which held sway up to as recently as 1950. The improved varieties of capsularis released and accepted by States are JRC 321, 212

and 7447. Similar varieties for *olitorius* are JRR 878, 7835 and 632. These varieties are capable of yielding 3-4 tonnes per hectare with suitable agronomic practices and irrigation. Some important results of research are summarised below :

Agronomy

(i) Uptake of nutrients by jute and mesta was not precisely known until 1968. The NPK ratio was fixed earlier arbitarily as 2:1:1. This ratio now stands changed to 2:1:2 in the light of recent soil surveys. When nitrogen is in short supply or when a dry spell continues and subsequently crop growth is arrested or for any other reason top dressing is either not possible or considered not beneficial, foliar application of urea as water spray is found to be beneficial. The application of potash could be raised further wherever soils are more deficient in this element, e.g., in parts of North Bengal and Assam. Similarly, the addition of magnesium to soils deficient in this element, e.g., those of 24-Parganas and Kamrup, improves the yield significantly. An average crop of jute lifts around 35-40 kg of Mg per hectare. Magenesium sulphate or dolomite proves good for the purpose. The latter is specially suitable for acid tracts of Assam and red soils having low pH.

(ii) Spacing plays a significant role in determining the quality of fibre. Technological tests show that, other things being equal, plants having a base diameter between 8 and 18 mm produce better quality fibre as against those having thicker stem. The plants of desired thickness can be obtained by manipulating spacing.

(iii) Many experiments have been conducted on the water requirement of jute crops and economic schedules have been worked out. One pre-sowing irrigation followed by two post emergence irrigations is found to be optimum. However, the third irrigation can be dropped if there is water scarcity. The importance of this finding lies in the fact that water thus economised can be diverted to other crops. In variety-cum-irrigation-cum-fertiliser trials conducted during 1966 and 1967, the average yield in control was 1.7 tonnes/ha in *capsularis* and 2.7 tonnes/ha in *olitorius*, whereas 3 irrigations coupled with 80 kg N/ha yielded as high as 3.2 tonnes/ha in *capsularis* and 4.0 tonnes/ha in *olitorius*, the increase in two species being 88

and 48 per cent respectively.

(iv) Removal of weeds is commonly done at present manually and it accounts for 30-40 per cent of the total cost of cultivation. Chemical methods of control are less costly and more effective and these also take away much of the tedium of manual operation. It has been demonstrated in experiments with weedicides that preplanting treatment with sodium 2, 2, 3, 3-tetrafluoropropionate gives the much desired initial freedom of competition from weeds to jute and later disodium methylarsonate or monosodium methylarsonate in combination with dalapon or alone can efficiently keep down later growth, if any.

(v) Often times cultivators are tempted to grow food crops in preference to jute. Because of this, scientists have made special efforts to evolve rotations which would enable the cultivation of other crops besides jute on the same piece of land. Some such rotations are jute-paddy-wheat, jute-paddy-paddy alone or with moong-paddy-potato.

Plant Protection

(vi) The emphasis upto 1966 was mainly on a study of the life cycle of various pests with special reference to the destructive phase on the crop. Control measures were also evolved wherever possible. However, pests like semilooper, stem-weevil, red mite, yellow mite, cricket and rot-knot nematode have continued to pose problems. In regard to diseases, persistent efforts have indicated that the fungus *Macrophomina phaseoli* causing stem rot (dry rot) is not so responsive to curative measures as to preventive ones. It has been possible to reduce and also stop incidence of stem and root rot by correction of soil acidity, application of potash and by improving soil organic matter. Seed treatment with organomercuric compounds and non-mercurials has been found effective. The mode of transmission of jute remains the most eluding problem. It is a serious This finding has helped keeping the foundation seed free from virus through roguing in early stages. 'Hooghly wilt' of jute remains the most eluding problem. It is a serious disease restricted to fields growing jute and potato in turn.

Technology

(vii) Fabrication of ribboning machines and decorticators has

been engaging attention of JARI and JTRL. A ribboning machine separates the fibre containing bark from stem. The ribbon so removed is just 20 per cent by volume and 40 per cent by weight of the whole plant. The decorticator helps in separation of the fibre from other tissues, and fibre thus separated requires to be washed just for 72 hours as against about a fortnight needed in the usual retting process. A combined use of ribboning machine and decorticator has the potentiality of doing away with large quantity of water and space needed in the usual method of retting and fibre extraction.

(viii) Techniques have been developed for assessing spinning quality of fibre from small scale spinning trials on standard spinning machinery and instruments have been designed for measuring important fibre characters. A large number of strength testers designed by the JTRL are in use in jute mills, and research and development centres. The techniques had been of much help in evolving good jute strains and norms for agricultural practices, such as, (a) keeping the dose of nitrogen in fertiliser within recommended limits since higher dose lowers jute fibre quality (b) sowing jute seeds in narrow spacings, since this produces thin plants giving fibre of very good quality along with increased plant population and (c) harvesting jute early and leaving the plot for other crops, since fibre from early harvested crop is in no way inferior in quality.

22.5.15 The real bottleneck in the case of this crop seems to have been the slow pace of development and extension activities. Although jute development programme was launched in the Second Five Year Plan, yet beginning towards a well conceived jute development policy was made only during the Fourth Plan period. The programmes aimed at concentrated efforts on the use of all recommended inputs in potential zones in order to increase yield through package approach. Provision was also there for additional retting facilities for improvement of fibre quality. The extent of achievement by the end of 1971-72 was as follows :

(i) extension of package programme to 90,000 ha under jute and 18,000 ha under mesta,

(ii) Saturation of 150,000 ha by improved seed, and

(iii) aerial spraying of urea on 16,000 ha.

The measures which have been contemplated for improving production during the Fifth Plan period consist of (a) increasing irrigated area, (b) supplying lime etc. at cheaper rates for neutralising acidity, (c) higher coverage under improved varieties (the present coverage under

improved varieties being only 20 per cent), (d) regular and timely supply of fertilisers with facilities of storage at road and rail junctions, (e) plant protection and (f) publicity in regional languages about the efficacy of weeding and thinning. It is expected that the yield level of this crop can be raised to about 2 tonnes per hectare by these measures by the end of the Fifth Plan period. It automatically enjoins that special emphasis should be laid on extension measures to popularise all the known beneficial research results and associated techniques applicable to this crop.

22.5.16 There is a feeling that the production of nucleus and foundation seed is inadequate, because of which the certified seed is in short supply. It is said that the National Seeds Corporation enjoys certain advantages which discourage other agencies to risk seed production. It is felt that there is need to establish additional nucleus jute seed multiplication farms. We have left enough initiative in the hands of the State Governments in our Interim Report on Multiplication and Production of Quality Seed pertaining to High Yielding Varieties and Hybrids of Cereals to formulate measures for adequate production of foundation and certified seed and we have covered many other aspects in Chapter 47 on Seeds. With all this, it should be possible to plan any step including the setting up of new farms for nucleus seed production. There does not seem to be need for any separate recommendation here on this matter. What is necessary is the availability of sufficient quantity of quality seed so that it should not prove a constraint in putting more area under better varieties. It is learnt that cultivators normally prefer to have fresh seed for raising a fibre crop but results of research denote that fibre crop can be raised from two years old seed provided germinability is not impaired below 80 per cent. This once again is a topic for the extension agencies to lay emphasis upon so that the seed in short supply can be made to cover more area. By covering the full area with better varieties and other inputs, putting the beneficial results of research to practice in field and ensuring optimum soil moisture conditions through rainfall or irrigation, there is no reason why the average yield should not ultimately reach a level of 3 to 4 tonnes per hectare, which has already been attained in experimental and demonstration plots. Despite these possibilities, we are in favour of accepting an yield standard of 2.75 tonnes/ha for the irrigated crop and 2 tonnes/ha for the rainfed crop in 2000 AD. The total yield of raw fibre in this manner will be 2.6 million tonnes.

Mesta

22.5.17 Mesta, sannhemp and jute are all plants known to India since ages past. There is record that experiments were carried out on

mesta as early as between 1784 and 1790 in Madras and later in the East India Company's gardens near Calcutta. Since then, this plant has been drawing attention of experimenters, whenever work on fibre plants has been considered. It has generally been grown as a sole crop in Andhra Pradesh and in other parts, it was grown mostly as a mixed crop with jowar, bajra, rice and often cotton and also as a border plant in sugarcane, maize and some other crops. However, pointed attention on this crop came to be devoted only after the partition of the country, when substitutes to jute had to be seriously considered in order to feed the jute mills of Calcutta. In addition to the traditional mesta areas, cultivators in many jute growing districts also took up its production. The average outlay in labour and material is much less in mesta than in jute cultivation and because of this reason, although it yields poorer than jute, jute growers got attracted towards it. Even though it grows equally well in the type of climate needed for jute cultivation, yet it is capable of thriving under conditions which would not suit jute without irrigation.[1]

22.5.18 Published data on this crop are available since 1952-53. Its all-India area was of the order of 200 thousand ha upto 1955-56, then between 1956-57 and 1960-61 300 thousand ha, between 1961-62 and 1964-65 400 thousand ha and between 1965-66 and 1971-72 320 thousand ha. The all-India yield has generally varied between 6 and 7 quintals per hectare, although in certain intermittent periods, e.g., 1954-55 to 1956-57 and 1961-62 to 1964-65, it even ranged between 8 and 9 quintals per hectare. Averages of area, production and yield for different States for the seven years ending 1971-72 are presented in Appendix 22.5—Statement III. The main features of this crop are stated below :

(i) The averages of all-India area, production and yield are 319 thousand ha, 211 thousand tonnes and 6.6 quintals/ha respectively.

(ii) The jute producing States in the east, viz., Bihar, Orissa, West Bengal and Assam etc. account for 45 per cent of area under mesta, 59 per cent of production and their overall average yield is about 9 quintals/ha.

(iii) Andhra Pradesh and Maharashtra account for another 43 per cent of area and 35 per cent of production of mesta. The yield in Andhra Pradesh is 6.7 quintals/ha, but it is only 3 quintals/ha in Maharashtra.

22.5.19 Of the individual States, Andhra Pradesh has the largest area of 89,000 ha representing about 28 per cent of all-India and West Bengal comes next, with 61,000 ha representing 19 per cent of all-India area. However, their production is of the same order viz., 60,000 tonnes

1 Kundu B.C. 1964, Proceedings of the Second National Kenaf Conference, Department of State, Agency for International Development, Washington.

representing about 28 per cent of all-India. The yield standard is the best in West Bengal, touching 10 quintals per hectare. This is because the best possible attention has been given to this crop only at the Jute Agricultural Research Institute, Barrackpore. There was no known standard variety for either of the two mestas, viz., *Hibiscus sabdariffa* (mesta proper) and *H. cannabinus* (also known as Kenaf) at the time of partition of India. The Institute selected and developed RT 2 of the former species. The Institute also formulated agronomic practices for the cultivation of mesta. A new variety, viz., HS 4288, which yields 23 quintals with normal inputs has also been released recently. This variety has recorded a maximum yield upto 30 quintals per hectare. The Institute has developed HC 583 for the *Hibiscus cannabinus* type. This yields 20 to 26 quintals per hectare. A variety named AMV 1 has been developed at Amadalavalasa, a research station in Andhra Pradesh. Information gained at the JARI during the last two decades or so about improved techniques of cultivation and varieties which contribute to better yield of fibre, has been included in the National Demonstration Scheme and many of the recommendations are already known to farmers.

22.5.20 We feel that the area under mesta could be stabilised at the existing average figure of 320,000 ha. In so far as yield is concerned, the target for the eastern States of West Bengal, Bihar, Orissa and North Eastern Region could be kept at 15 quintals, for Andhra Pradesh at 12 quintals and for the rest of the mesta growing areas at 9 quintals per hectare. With these standards, the total all-India production in 2000 AD would aggregate to 400,000 tonnes which will give an average all-India yield of 12.5 quintals per hectare. In order to achieve this level of production, it is necessary that each of the concerned States develops its own research programme. It is difficult for a single station situated in one kind of environment to develop varieties and practices which will be suitable for other parts, specially the Peninsula. It is for this reason that the agricultural universities of the States concerned should be made directly responsible for all research programmes. However, they will need the co-operation from and co-ordination with the JARI, for which purpose an understanding has to be developed with the ICAR. The technological aspects will continue to be dealt with centrally at the JTRL.

Ramie

22.5.21 Ramie producing countries are Korea, Japan, Taiwan, China, Indo-China, Philippines and Brazil. China is perhaps the largest ramie producing country in the world. A report published in the Tropical Abstrat (1956) states that prior to the outbreak of war with

Japan, annual ramie production in China was estimated at 100,000 tonnes or 80 per cent of the world production and after 1949 the production exceeded the previous figure by 50 per cent. The recent production figures for China are not available. In 1961, the total world production of ramie except China stood at 14,851 tonnes from a total area of 17,312 ha. The fibre is still of secondary importance in international trade. It can only be said that the textile industry is ready to consume much more ramic fibre than what is produced at present. There is a great world demand for the fibre in view of its tremendous possibilities in textile industry. As early as 1962, the Export Promotion Directorate of the then Ministry of Commerce and Industry had addressed a letter to our trade representatives in forcign countrics in connection with the investigation of export possibilities for Indian ramie fibre. The replies indicated favourable response from many European countries, Canada, USA, South Rhodesia, Japan, Hong Kong and Australia.

22.5.22 Several European firms started plantations in Madras and Bihar in the later part of the 19th century and later in Assam, but their projects failed because of faulty cultivation methods and difficulties of fibre extraction in the absence of suitable decorticating machines. On two occasions, once in 1869 and again in 1877, the Government of India offered prizes (£5,000 and £2,000 in 1869 and £5,000 and £ 1,000 in 1877) for the development of efficient machinery or processes for the extraction of ramie fibre, but the offers were ultimately withdrawn after several unsuccessful trials. In 1896, Faure of France developed a hand-operated decorticator for hard fibres, which was later adapted for ramie and used extensively in Japan, Brazil and Philippines. Further improvements have been made since 1944 in USA, Japan, France, and West Germany and these have resulted in the development of highly efficient portable and stationary ramie decorticators.

22.5.23 In 1944, the Government of India appointed a Fibre Development Officer for exploring the possibilities of the development of fibres other than jute and cotton in the country. Information on ramie was presented in the form of a memorandum, which was later published as a miscellaneous bulletin of the Imperial Council of Agricultural Research, 1946. The report suggested some experimental plantations in Bengal and Assam. The Central Ramie Research Station at Sorbhog, Assam, was set up in 1960 by the Government of India on the recommendation of the ICJC. There is also a ramie farm maintained by the Department of Agriculture, West Bengal, at Mohitnagar. Experiments show that the quality of fibre produced is acceptable to the textile industry. The net income per hectare in five years came to about Rs. 23,000 when the selling price of the fibre was Rs. 650

per quintal. This indicates that there is no doubt about the profitability of the crop. The JARI has fabricated a decorticating machine suitable for ramie fibre. This is a favourable development because it will remove dependence on imported decorticators.

22.5.24 Areas having high rainfall and warm humid climate are very suited to this crop. It cannot tolerate waterlogging and severe winters. The soil should not be acidic; a good loamy soil is preferable for it. Ideal locations exist in Himalayan West Bengal and Assam. Some textile industries and tea gardens have already started their own ramie plantations in these parts, though on a small scale. However, we are not in favour of encouraging the tea plantations to take to this crop. The likely requirements of ramie fibre in the next few years have been estimated to be around 10,000 tonnes, for which an area of the order of 10,000 hectares is considered sufficient. It should not be difficult to carve out this much area in West Bengal and Assam or the adjoining States of Arunachal Pradesh, Meghalaya, Negaland, Manipur and Tripura. Even West Coast could be tried for this crop. Reclaimed acidic lands might suit this crop in West Bengal, Assam, etc. Researches on ramie could be continued by the IARI and the Central Ramie Research Station at Sorbhog for the time being. The JTRL should continue to look after the technological aspects.

22.5.25 Being a plantation crop, it requires heavy investment to begin with. It also occupies a field for about 6 to 8 years. Ordinary farmers may not be attracted by this crop in the beginning for these reasons. At the same time, the crop need not be confined to big planters only. Therefore, lands could be allotted in compact areas to small farmers who could be encouraged to form co-operatives in order to cultivate and manage this crop in an efficient manner. Governments of the States concerned should give all possible help and guidance to such co-operatives. Ramie plant is propagated through rhizomes. The planting material that can be available at present is barely sufficient to cover about 1,000 ha. Therefore, arrangements will have to be made to produce the requisite quality of seed material.

Sannhemp

22.5.26 Published data are available for this crop since 1957-58. Its area and production in the country between 1957-58 and 1964-65 were about 200,000 ha and 75,000 tonnes respectively. Corresponding figures for the period 1965-66 to 1971-72 average out to 166 thousand ha and 63 thousand tonnes. The average yield in both the periods has been 3.8 quintals/ha. Averages of Statewise data for the period 1965-66 to 1971-72 are contained in Appendix 22.5—Statement IV. It would appear that most of the States grow this crop sufficient to

meet their own needs and the production is usually less than 10 per cent of all-India excepting for the States of Uttar Pradesh and Madhya Pradesh. Uttar Pradesh is the major sannhemp growing State responsible for 36 per cent of area as well as production. Next comes Madhya Pradesh, which has 18 per cent of all-India area and 16 per cent of production.

22.5.27 In the Indian trade, sannhemp fibre is broadly classified into 3 distinct types, viz., white Ganjam, Green and Dewghuddy, their proportionate production being 56, 43 and 1 per cent respectively. White type is chiefly produced in the eastern districts of Uttar Pradesh and western Bihar. About 10,000 tonnes of special Banaras white grade is produced at present in the four districts of Uttar Pradesh, viz., Varanasi, Pratapgarh, Allahabad and Jaunpur. Of this, about 5,500 tonnes is baled under Agmark at Varanasi for export or for the manufacture of tissue papers. The demand for white type has greatly risen now because of its use in the manufacture of security and other kinds of tissue papers. The production of Ganjam Green is concentrated in Pilibhit and Moradabad districts of Uttar Pradesh. This type is stronger than the white fibre and, therefore, is preferred in the manufacture of ropes and twines. It gets a premium of as much as 40 to 50 per cent in price over the average quality of white fibre. Dewghuddy type is also better in strength than the white type and, therefore, fetches prices upto about 75 per cent or more, but it is of no consequence because of negligible area under it. The three types of sannhemp fibre as distinguished in trade were at one time considered to belong to different species, e.g., *Crotalaria juncea* and *C. tenuifolia*. However, the consensus at present is that all these types come from *juncea*.

22.5.28 In scientific attention, sannhemp is a neglected crop on the whole just like mesta. In this case, there has been an additional handicap that it is highly cross-pollinated, because of which it is difficult to maintain in purity of line. Individual scientists have given attention to this crop in many parts of the country from time to time. Concentrated attention has been confined to only a few stations among which Kanpur can be mentioned specially. The *ad hoc* Advisory Committee on Sannhemp was set up in March 1960 by the then Ministry of Commerce and Industry for considering methods to improve the yield and quality of fibre. As a result of its recommendations, a Sannhemp Research Station was established at Pratapgarh in Uttar Pradesh in 1963 by the Indian Central Jute Committee. It functions as a sub-station of the Jute Agricultural Research Institute, Barrackpore. Despite the work of the Pratapgarh station or what has been directly done at Barrackpore, it is difficult to mark out any outstanding impact of improved varieties or practices in the cultivators' fields in general. Various admixtures of inferior types are still continued to be

grown and the crop is generally cultivated without any serious attention.

22.5.29 We propose that the area be stabilized at the existing level of about 170,000 ha and attempts should be made to double the yield standards. It should not be difficult at all even to treble it with concerted efforts. We feel that, for achieving this, it is absolutely essential that the onus of research work should directly lie with the State in which its results are meant to be applied. It does not appear to be easy to supervise and conduct the work in an effective manner at Pratapgarh from a distant place like Barrackpore. It will be better if the responsibility of research work for Uttar Pradesh is entrusted to the different agricultural universities of Uttar Pradesh regionwise and the Pratapgarh station is suitably absorbed in their setup. Similarly, the agricultural universities in other States should look after the problems pertaining to sannhemp typical to their regions. As we have said in the case of mesta, the role of the JARI should be confined to cooperation and coordination only. The technological aspects should continue to be dealt with centrally at the JTRL.

22.5.30 The topmost problem in the case of sannhemp, which should receive attention of the agricultural universities, should be how to break the barrier of self-sterility and bring forth durable hybrids or synthetics. Another problem which requires due attention is the development of varieties separately for green manuring and fibre purposes. Strength of tissue is the main consideration in the case of fibre types, whereas softness of tissue is a very desirable quality for the purpose of green manuring. Green manuring also requires prolific development of leaves and branching would not be a handicap, provided the shoots are tender. On the other hand, branching is not desirable quality for fibre types. At present, cultivators hardly make a distinction in practice between the two purposes. This defect has to be removed both with research and development work. The third important problem relates to special measures which are required to be undertaken in the seed multiplication programme in order to see that deterioration, which is inherent owing to cross-pollination in course of time does not affect the quality of seed meant for distribution.

Flax

22.5.31 The fibre of the linseed plant, *Linum usitatissimum,* is commercially known as flax in the West. The fibre yielding varieties are different from the oil yielding ones. Attempts to cultivate flax in India in the interior parts of Bengal and Bihar can be traced to the beginning of the 19th century. Even a company was established for this purpose in 1839 and variety Riga was tried. The Bihar Planters

Association made attempts to grow flax in 1906 under the supervision of a Belgian flax expert at Dooriah near Pusa. Some trials were made about the same time in Bengal, Uttar Pradesh, Punjab and Madhya Pradesh using both the Indian linseed types and European flax types. The IARI tried a famous Irish flax variety JWS in 1924 and this was also tried at some 5 selected centres in Bengal in 1928 by the Director of Agriculture, Bengal. Richaria (1950) made a systematic study of some world collections of linseed and flax types. He classified the varieties into two broad divisions, viz., flax varieties and seed varieties. The former possessed tall and comparatively unbranched thin straw with poor seed yield. The latter was characterised by dwarf and very much branched straw with very high seed yield. Richaria made emphasis on utilising the country's linseed straw, which otherwise goes waste after seed collection than to try a flax variety. He was convinced that the introduction of flax varieties would not meet with success in general under Indian conditions.

22.5.32 Recent work of the JARI confirms that flax type can be attempted with success only in such parts of the country which have cool climate, e.g., Jammu & Kashmir, Himachal Pradesh, West Uttar Pradesh hills and Arunachal Pradesh. But for this, attempt should be utilisation of the straw of seed types even according to JARI. Utilisation of straw will be considered elsewhere appropriately. Insofar as the fibre aspect is concerned, attempts should certainly be made to grow it commercially in the temperate parts of the country. The JARI is continuing its efforts to select some promising types. A target of 5,000 ha may be fixed for linseed to be grown for the purpose of fibre to begin with and this position may be reviewed later on in the light of actual experience.

Agave

22.5.33 Agave consists of many species, e.g., *sisalana, fourcroydes, cantala* and *wightil*. The commercial fibre is popularly known as either 'sisal' or 'henequen', both the terms originating from Mexico, from where the earliest supplies of this fibre used to be exported. The two terms have sometimes been used synonymously, but 'sisal' is usually identified with *sisalana* and 'henequen' *fourcroydes*. The FAO treats sisal separately and combines other species together for the sake of reporting data. The average figures of production of sisal in the world during the period 1970-72 are reported in thousand hectares as 180, 162, 208 and 87 for Tanzania, other African countries, Brazil and other countries respectively.[1] The world production of other kinds of agave fibre is of the order of 161,000 hectares, out of which Mexico alone acc-

1 Nafiz Erus (Editor) (1972), FAO Production Year Book Vol. 26, 1972, Italy.

ounts for 143,000 hectares.[1] The countries which individually account for considerable proportion of the total production are Tanzania, Brazil and Mexico.

22.5.34 Agave was introduced in India by the Portuguese between the 16th and 18th centuries, but it never gained any prominence. Various species have been grown in a sporadic manner as hedge plants along the banks of railways, gardens, fields etc. Regular cultivation of this crop for commercial exploitation has been very limited and the species used for this purpose has been mostly *sisalana*. Whatever plantations have existed are far and wide apart and represent a neglected state; these are found on poor soils and, therefore, are mostly uneconomic. There are about 3,000 hectares under agave plantations at present distributed over Orissa (1,201 hectares), West Bengal (416 hectares), Andhra Pradesh (579 hectares), Maharashtra (726 hectares), Madhya Pradesh (50 hectares) and Bihar (30 hectares). No precise estimate of annual production of agave fibre is available in the country. It is roughly estimated to be around 2,500 tonnes.

22.5.35 Because of the general neglect of the plant in the country, a belief has developed that agave can grow anywhere and thrives under desert conditions. While it is true that certain types like *Agave lachuguilla* can stand xerophytic conditions and a country like Israel does grow them, the plant in general requires at least 78 cm of rainfall well distributed over the year for a good fibre crop. It also requires large quantities of fertilisers. Another pre-requisite for the successful cultivation of this crop is the large size of plantation. Use of decorticators and other machines becomes economical when the estates are located in a compact area and the size of individual estates is large. It may be observed that the countries, which are running commercially successful sisal estates, were all once colonies of European countries because of which acquiring of vast areas of fertile land and cheap labour became easily possible. The size of an estate in Tanzania and Kenya may be anywhere between 600 and 4,000 hectares. Keeping in view the economic viability and the fact that agave flowers once in ten years and after flowering the plant dies out, it is considered that the minimum size of a plantation for this country could be 100 hectares in order to enable phasing out of planting for maintaining continuity of production. Agave starts giving economic returns from the 4th year of planting. Because of this reason, the area under young and bearing agave can be kept at 30 and 70 ha respectively in a plantation of 100 ha. There could be an annual rotational programme of planting in one-seventh of the area of bearing agave (i.e. in 10 ha per year). Adding another 5 hectares under nursery, roads, buildings etc., the total size of a unit may be 105 hectares. It may be stated in this connection that the plantings of agave

1 Nafiz Erus (Editor) (1972). FAO Production Year Book Vol. 26, 1972, Italy.

crop are made with bulbils on suckers, because seed is usually not available due to rare flowering.

22.5.36 Meaningful research on this crop has emanated from the East African countries, particularly the United Republic of Tanzania and Kenya. Optimum conditions for the successful cultivation of the crop on scientific lines have been determined and in spite of the very limited opportunities that arise in the crossing of different species due to lack of synchronization of flowering and long intervals between each flowering, improvement in effecting higher yields of fibre by evolving high yielding varieties by crossing was attempted in Tanzania. As a result, a hybrid (viz. 11,648) is now available with all the ideal characteristics of a high yielding type, such a prolific leaf production, rigid leaves, smooth margins, rapid growth and early development, hardiness and adaptability, easy cultivation, responsiveness to high doses of fertilization and good leaf dimensions. The only flaw with this hybrid is that it is not very resistant to diseases and pests, especially the zebra disease and weevil attack. The hybrid has a high yield potential upto 79.0 tonnes of fibre per hectare in a cycle of about 11 years i.e., about 7 tonnes of fibre per hectare per year.

22.5.37 Very little research work on this crop existed in the country and the crop has been grown on the basis of knowledge derived from other countries. An Expert Sub-committee was appointed by the ICJC in 1959 to examine matters relating to increasing production of agave fibre. It recommended the establishment of a Central Research Station for this crop. It also recommended that an area of 20,000 hectares should be brought under agave cultivation in the States of Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, West Bengal, Maharashtra, Andhra Pradesh and Karnataka. Orissa and Bihar were to have 4,000 ha each and the remaining States, 2,000 ha each. The Union Ministry of Agriculture and Irrigation initiated action on the various recommendations made by the Committee. For carrying out research, a Central Sisal Research Station was setup at Bamra in Sambalpur District of Orissa in 1962. A model scheme was circulated among the concerned States, but the practical effect bears no proportion to the envisaged target. The Bamra research station is an ICAR station and works under the control of the Central Jute Research Institute, Barrackpore. Besides Bamra, some of the State Governments maintain their own agave farms, whose number is approximately like this: Orissa 10, West Bengal 3, and one each in Madhya Pradesh, Bihar and Andhra Pradesh.

22.5.38 The Expert Sub-committee mentioned above had estimated India's annual requirement of agave fibre at 15,000 tonnes. A committee, in October 1965, comprising officials of the Ministry of Defence, Ministry of Commerce, Planning Commission and Ministry of Agri-

culture considered the defence needs of agave fibre and put them at 1,000 tonnes over and above civilian requirements. Very recently, the Indian Institute of Foreign Trade, which conducted a study and survey of Orissa for export potential, assessed the annual requirement of agave fibre at 16,000 tonnes. This combines and corroborates the earlier two estimates. The current estimated annual production being 2,500 tonnes, there is a deficit of 13,000 tonnes. The deficit has always been met by resort to imports. The imports varied between 3 and 7 thousand tonnes between 1961-62 and 1968-69 and, therefore, even these were not sufficient to meet the country's full needs. It is only in 1969-70 and 1970-71 that the imports have increased to 10 and 13 thousand tonnes respectively. Even now, it is said that about 40 per cent of the installed capacity in the rope manufacturing industry lies idle and some of the units are mixing inferior material in preparing agave ropes. The country has managed to export some quantity of manufactured ropes and twines in spite of its tight internal supply position. The export of rope was about 70 tonnes in 1966-67 and 680 tonnes in 1968-69. As the situation is today, the foremost need is for self-sufficiency rather than to aim for export. If 40 per cent of idle capacity is also taken into consideration, the total requirements for the present will work out to be 22,400 tonnes. One can easily expect to double this requirement by 2000 AD.

22.5.39 If the present production of 2,500 tonnes comes from 3,000 ha, the prevailing standard of yield works out to be of the order of 0.8 tonne/ha. An yield standard of 2.5 tonnes/ha has already been attained at Bamra with the package of improved practices of cultivation. Keeping this in view, it seems justified to assume an yield rate of 1 tonne/ha even to begin with. At this rate, the area required to meet the present need will be 22,400 ha. An area of 22,000 ha has already been recommended earlier by the 1959 Expert Sub-committee and, therefore, it seems quite sufficient to make a beginning with this much as a target. In course of time when the general yield of plantations can be made to rise to 2.5 tonnes/ha, an area of 20,000 ha itself will be able to give an outturn of 50,000 tonnes, which is even slightly higher than the target for 2000 AD. Agave hybrid number 11,648 has an yield potential of 7 tonnes/ha. If it is popularised in India, it could change the perspective so much that the area under agave may have to be even reduced at some later stages. However, such a contingency will arise only after the achievement of practical results. Meanwhile, the Ministry of Agriculture and Irrigation and the Departments of Agriculture of the States concerned should once more attempt to fulfil the targets of area as laid down by the 1959 Expert Sub-committee. It will also be worthwhile to try some xerophytic types in area of scanty rainfall specially in Rajasthan. The ICAR may have to give preliminary

attention for research in this regard before the States are actually asked to take up agave cultivation in dry areas.

22.5.40 It has already been shown that the minimum viable unit of agave plantation has to be of 105 ha. Land ceilings being enforced in almost all States leave very little scope for individual ventures of this size. The competition from Tanzania and Kenya is also real because of which even some of the prosperous individuals who possess large estates do not like to risk investments. Even then, we are not in favour of direct governmental involvement. Therefore, the only alternative left for this purpose is the formation of cooperatives consisting of small enterprising farmers. Insofar as the land problem is concerned, some of the Government lands could be considered for allotment to such societies on nominal rent. A hundred-hectare farm is expected to give a net income of about Rs. 80,000 per year on an average, even when production is calculated in the range of 0.8 to 1.75 tonnes/ha. This includes the contribution of fibre as well as proceeds from bulbils and suckers (Appendix 21.5—Statement V). This can give an average income of Rs. 1,000 per month per head to a group of 6 persons. Agricultural graduates will have an advantage over others to manage this crop because of the many technicalities involved both in crop production as well as fibre extraction and, therefore, such a venture can open a new avenue of self-employment for them. As such, agricultural graduates should be given preference in establishing agave plantations.

22.5.41 One of the bottlenecks that is being encountered in the expansion of the area under this crop is the non-availability of sufficient quantities of planting material. Madhya Pradesh and Bihar have faced difficulties in the procurement of planting material of the existing standard type *Agave sisalana*. Even Orissa is not in a position to meet its requirements for achieving the annual targets of plantation. At present, it is left only to the Sisal Research Station, Bamra, which is not able to meet the full requirements of various States. It is necessary that nurseries for planting material are established in every State in order to make them self-sufficient in this regard. This can be done directly under the aegis of the Department of Agriculture. The nursery stations can also be made to undertake adaptive research work pertaining to their respective regions. The Bamra Sisal Research Station of the ICAR can make only the initial supply of desirable varieties, otherwise it should concentrate only on research problems without involvement in the seed multiplication or supply work in general. The immediate supply work will have to be planned on the basis of high yielding varieties already popular in other countries. While selecting these, due care will have to be taken about their climatic suitability for different parts. However, the country should also plan for initiating its

own breeding work. Seed setting in this crop seems to require cool climate, which is not available at Bamra. Because of this reason, it is necessary to setup a sub-station at a higher altitude. It has been suggested to us that Vivekanand Laboratory, Almora, Uttar Pradesh, may be an ideal site. However, we leave open the matter of choice of station to the ICAR.

22.5.42 Breeding work has to aim at evolving such varieties which are suitable to the country from the point of view of yield, quality of fibre and resistance to pests and diseases. Some nutritional disorders like leaf wrinkling, leaf tip die back, chlorotic mottle and banding disease are rampant on agave in this country. These require attention, because their rectification by itself can increase yield by about 10—15 per cent. Another problem which needs attention with regard to this crop is the improvement of soils in order to render them more productive. This is necessary because the crop is mostly grown on poor soils; the idle lands which we have proposed for further extension will also be mostly marginal or sub-marginal. The Sisal Research Station at Milingano (Tanzania) is understood to have built up expertise in the field of agronomy and decortication techniques. Arrangements could be made with this and some other similarly advanced research institutions for training facilities for our scientists so that they can introduce the latest know-how in their research efforts.

22.5.43 Extension of area under agave is being planned more or less from a scratch. Research knowledge directly applicable to the conditions prevailing in this country is not available at present to an appreciable extent. It will be advantageous if the basic work is continued to be done for the time being at Bamra Sub-station of the JARI. Insofar as the States are concerned, it has already been suggested that each State should have its own station with facilities for raising nursery and doing adaptive type of research work. However, for the propagation of agave in dry conditions, the Central Arid Zone Research Institute at Jodhpur and the University of Udaipur or any other Agricultural University, which may be established in Rajasthan, should undertake the responsibility of connected research work. The technological aspects relating to agave should be continued to be dealt with by the Jute Technological Research Laboratories.

6 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

22.6.1 The targets of area and yield for the various commercial crops as contemplated for 2000 AD are presented in Appendix

22.6—Statement I. The present position has also been indicated for the sake of comparison. The salient features pertaining to area changes are stated below :

(i) The major areas under groundnut will have to continue under rainfed conditions only. Because of this reason, the extension of area under groundnut should be effected as far as possible, (a) in such parts which receive rainfall of 10 to 20 cm per month in three or all of the Southwest monsoon months of June to September or, (b) where it is 20-30 cm per month in two of these four months (*i.e.* B2-C4/C3) or, (c) in the south where the rainfall of September to November ranges between 5 and 20 cm per month (Sept 20-30 cm, Oct 20-30 or 10-20 cm, Nov 5-10 cm).

(Paragraph 22.1.7)

(ii) The area increase in sesamum crop should preferably take place in such rainfall zones where the Southwest monsoon months involve rainfall of 10 to 20 cm or 20 to 30 cm for atleast one month (*i.e.*, between B1 and C1 types of rainfall patterns).

(Paragraph 22.1.8)

(iii) The area increase for niger should take care of the possibility of utilising the wheat fallows of Madhya Pradesh.

(Paragraph 22.1.9)

(iv) 50 per cent of the total proposed area for brassicas should come under irrigation. The crop in Uttar Pradesh should get utmost attention in this respect.

(Paragraph 22.1.11)

(v) Safflower can suit paddy fallows in majority of the paddy growing areas. It can be a fit substitute for lathyrus in Madhya Pradesh, Bihar and West Bengal.

(Paragraph 22.1.13)

(vi) Soyabean can be considered as one of the substitute crops in such areas where rainfall, though high, is not adequate for paddy all through. It can be considered with irrigation even in other situations in preference to pulses like horsegram.

(Paragraph 22.1.16)

(vii) Out of the total area of 2.0 Mha under sunflower, only 0.75 could be put under irrigation, the rest will have to be raised under rainfed conditions as an early *kharif* crop in general (wherever possible) and late *kharif* crop with the help of September-October rains in the

south.

(Paragraph 22.1.18)

(viii) Sugarbeet could be specially considered in the North-western parts comprising Jammu & Kashmir, Himachal Pradesh, west Uttar Pradesh, Punjab, Haryana and Rajasthan.

(Paragraph 22.2.12)

(ix) For sugarcane, about a million ha have to be added in the Peninsula and 1.5 Mha in other parts. Uttar Pradesh and Bihar can certainly take in more area but the needs of other promising States like Madhya Pradesh, Orissa and irrigated parts of Rajasthan should also be given due consideration.

(Paragraph 22.2.10)

(x) The districts of west Uttar Pradesh bear the same promise for cotton growing as is obtained in the States of Punjab and Haryana. An allocation of 0.8 Mha has been made for these districts. Cotton growing may also be encouraged in West Bengal, Bihar and Orissa. In these parts, the crop can be taken during the period December to April and, therefore, can be easily fitted into the paddy fallows.

(Paragraph 22.4.9)

(xi) Irrigation is at present the most important factor for increasing jute yields and eighty per cent of the proposed jute area is, therefore, recommended to be irrigated. Further, out of the remaining 0.2 Mha 0.1 Mha may be brought within a more assured rainfall distribution, which in practice involves a sowing date not later than the 15th of May. This may be tried on an experimental basis, and for this purpose early maturing varieties may be used.

(Paragraphs 22.5.11 & 22.5.13)

(xii) Ramie plantations may be established in the Himalayan West Bengal, Assam and other suitable parts of the North-eastern States. It could be tried even along the west coast. The advantage of starting these plantations could be given to small farmers by encouraging them to form cooperatives. Planting material sufficient for the purpose may be produced in time.

(Paragraph 22.5.25)

(xiii) The Ministry of Agriculture and Irrigation should ensure the fulfilment of the area targets under agave recommended by the Expert Sub-committee appointed by the Indian

Central Jute Committee in 1959.

(Paragraph 22.5.37)

22.6.2 Recommendations on general, research and developmental aspects of oilseed crops are as under :—

(i) Due attention should be given to all oilseed field crops in order to increase their production capabilities. Many of the known results of research should be extended to them immediately and in the case of groundnut and brassicas, extension efforts should aim at covering the entire area with useful practices as quickly as possible.

(Paragraph 22.1.4)

(ii) Groundnut : As it may not always be possible to allot the best lands to this crop, agronomic techniques to be developed should be able to give maximum possible returns under different kinds of soil. The crop could be given an early start in the *Kharif* season with the help of irrigation, atleast in some project areas as an experiment.

(Paragraph 22.1.7)

(iii) In order to raise the yield standards of groundnut, it is necessary : (a) to develop better drainage in fields in high rainfall areas, (b) to take all possible measures for conserving soil moisture in low rainfall areas, (c) to adjust growing season to fit into local rainfall rhythm, and (d) to increase plant population per unit area.

(Paragraph 22.1.7)

(iv) Sesamum : In the case of sesamum the main strategy for increasing the yield will be the improvement of drainage conditions in high rainfall areas and the better utilisation of rainfall facilities elsewhere.

(Paragraph 22.1.8)

(v) Niger : High yielding Ethiopian varieties could be introduced directly after testing or used for improvement of Indian varieties through hybridisation.

(Paragraph 22.1.9)

(vi) Soyabean : For popularising soyabean, an alternative to the exotic varieties can be to try the indigenous hilly varieties. The latter have the advantage of being accepted as a pulse, while the former do not have this and, therefore, indigenous varieties can be sold as pulse when the oil industry fails to utilise due quantity. Researches in this direction are desirable. Attempts to introduce disease resistance in new varieties, specially against mosaic should continue.

(Paragraphs 22.1.15 & 22.1.16)

(vii) In the extension programme of soyabean, the spheres of utility of this commodity should also be expanded. For example, popularising a blended mixture of wheat and soyabean flours, putting to use the soyabean flour and meal in confectionary articles and exploiting soyabean for the manufacture of vegetable milk are some new uses. It may be pointed out here that groundnut cake has also the same potentialities.

[Paragraphs 22.1.15 & 22.1.20(i)]

(viii) Sunflower : Seed-setting, seed viability and soil content of seed require to be improved. Since better pollination through the agency of honeybees could be an effective answer to proper seed-setting this factor should be studied thoroughly. Other responsible factors, if any for seed setting and viability should also be studied.

(Paragraph 22.1.17)

(ix) Utilisation of oilseed cakes : Cotton seed and rice bran, which should rightly be given preference for obtaining oil, are at present used for livestock feeding. Extension agencies should see that the farmers get accustomed to feed their animals with the cake or meal of these subsidiary products which are equally nutritive or even better.

(Paragraph 22.1.19)

(x) The full utilisation of cake or meal of all the oilseeds in general is an imperative necessity, because if the cake is not disposed it will discourage the further offtake of oilseeds for crushing and in turn to the very cultivation of oilseeds themselves. The maximum utilisation of cakes should be for livestock feeding. Utilisation of cakes as manure and for preparation of germicides and pest repellants may be developed and popularised. Internal demand and export may be properly balanced so that annual fluctuations in the quantity exported are avoided as far as possible.

(Paragraph 22.1.20)

(xi) Organisation : For giving proper attention to oilseed crops, there is need for four well-coordinated wings, one each to deal with (a) field crops, (b) subsidiary oil bearing products of field crops, (c) oil-bearing shrubs and trees, and (d) byproducts of oil industry. These wings may be set up both on the research and production side *i.e.* in the ICAR as well as in the Union Ministry of Agriculture and Irrigation. A similar operational set-up may be created in the State Departments of Agriculture with due participation

of the agricultural universities on research side. A Central Technological Laboratory for oilseeds and their by-products is also necessary and this may function under the ICAR.

(Paragraph 22.1.21)

(xii) Each State should be fully responsible for research as well as developmental work on the oilseed crops of their region. Regional coordination should in the first instance be organised among the contiguous States having identical crops and identical problems. The central coordination should be confined to problems of all India nature only and the Oilseeds Developments Council at the Centre should be a broad based apex body charged with this responsibility. Its composition could include representatives of the States, ICAR, Union Ministries of Agriculture, Industry and Civil Supplies and Commerce, Forest Research Institute, Dehra Dun, Khadi and Village Industries Commission and oil millers. The States may also have similar apex bodies with representation from the agricultural universities, Departments of Agriculture, Horticulture, Plantation Crops (if any), Forests, Industries, Khadi and Village Industries Board, representatives of oil industry and growers. It is this body which could represent a State on the Central apex body as well as in the inter-State coordinating councils.

(Paragraph 22.1.22)

22.6.3 Recommendations pertainings to other commercial crops are summarised below :—

(i) Sugarcane : Ratoon cropping may be encouraged because it reduces cost of cultivation. As the ratoon crop has to be given as much attention as the plant crop separate agronomic and plant protection schedules should be drawn up for both of them.

[Paragraph 22.2.4 and 22.2.5(v)]

(ii) Varieties have to be bred separately for (a) plant and ratoon crops and (b) *gur* and white sugar. Varieties of the future should have the highest possible sugar recovery, tillering capacity and tolerance to high population stress. Agronomy has to aim at maximum percentage of germination, least mortality and the maintenance of an optimum plant stand up to the end. In the field of plant protection, efforts have to be continued for introducing genetic resistance and for finding out effective methods of chemical control, while biological methods of control also require to be developed and put into practice. Biochemical techniques

should be developed for stimulating ripening in adverse circumstances.

(Paragraph 22.2.5)

(iii) Research activities other than breeding should be made the responsibility of the agricultural universities in order to render effective solution of regional problems. Breeding aspects in sugarcane presents, of course, a special problem, viz., that of flowering, because of which Coimbatore has to continue to play a central role in hybridization work. Hebbal (Bangalore) is another station not far away from Coimbatore which has shown promise in this type of work and it may also be fully developed as a companion station to Coimbatore. Hebbal can specifically look to the breeding needs of the southern States and Coimbatore should have an all-India slant, more directed to northern needs. The Sugarcane Research Institute, Lucknow, has to develop as a sister station alongwith Coimbatore specialising in selection and development of suitable varieties after the 'fluff' stage for the northern parts of the country.

(Paragraph 22.2.6)

(iv) Multiplication and distribution of disease-free planting material of sugarcane should be given special attention because the existing stock is highly degenerated and disease-ridden.

(Paragraph 22.2.8)

(v) The developmental activities pertaining to sugarcane should be the responsibility of the Director of Agriculture on a uniform pattern in all the States including Uttar Pradesh. The Departments of Agriculture should look to all round development of sugarcane—whether it is for sugar or *gur* or *khandsari* manufacture. Even the industrial aspects with regard to the production of sugar or *gur* or *khandsari* may be looked after by the Department of Agriculture by creating a special cell for the purpose.

(Paragraph 22.2.8)

(vi) Sugar factories should be encouraged to participate directly in promotional and advisory activities on the developmental side as much as in procurement activities in their concerned areas to the maximum possible extent. It should be made mandatory for the factories to have a Cane Development Wing for this role. Such a wing in every factory should have a Cane Development Officer in the same way as a Chief Chemist or a Chief Engineer. The

functions of such a wing should relate to the provision of all inputs including credit in the factory area. It should advise growers on all aspects of sugarcane cultivation. It should have its own mechanised units available for operations on the growers' fields at appropriate charges. In short, a very effective and intimate two-way direct contact between the grower and miller should develop. Governmental involvement in these matters should be limited to a supervisory role.

(Paragraph 22.2.9)

(vii) Tobacco : Varietywise and usagewise area and production statistics of tobacco has to be collected. Collaboration between the Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation and Directorate of Statistics and Intelligence in the Department of Central Excise and Customs is desirable for this purpose.

(Paragraph 22.3.5)

(viii) Future research work should be in the direction of achieving higher yields per plant and per unit area of land under all kinds of tobaccos. Air-cured and/or aromatic tobaccos like Burley, *Natu* and *Lanka* which have better appeal from export point of view need encouragement. The agricultural Universities of the tobacco growing regions should be increasingly associated in future research work. Some specific aspects which require investigation are : (a) avoidance of harmful effects of irrigation on leaf quality due to the presence of chemicals in irrigation water, (b) biological control of pests and the role of harmless chemicals for use in plant protection work, e.g., fungicides of organic origin and (c) elimination or reduction of carcinogenic or other harmful properties of tobacco.

(Paragraphs 22.3.13 and 22.3.14)

(ix) Grading of tobacco leaves should be made compulsory, whether the product is meant for export or internal consumption. The system of grading tobacco leaves according to position on plant should be investigated with due regard to the economic operation of barns.

(Paragraph 22.3.14)

(x) The Ministry of Agriculture and Irrigation together with the concerned State Governments should make a review of all developmental activities (including extension and training) in order to make the development organisation effective in every important tobacco growing district for

increasing production of all kinds of tobacco.

(Paragraph 22.3.17)

(xi) Cotton : There is need to study why the cotton crop in Madhya Pradesh and Maharashtra is not able to perform as well as in Gujarat under the same pattern of rainfall distribution since irrigation does not fully explain the existing difference in performance.

(Paragraphs 22.4.4, 22.4.5 and 22.4.6)

(xii) The districts of poor performance of cotton, where sure support of irrigation is called for are Aurangabad (Maharashtra), Belgaum, Gulbarga, Dharwar (part), Bijapur, Raichur, Bellary, Chitradurga (Karnataka), Mahaboobnagar, Kurnool and Anantapur (Andhra Pradesh). Judicious use of rainfall and irrigation water, one supplementing the other, is the keynote on which future strategy should be based. This applies to other areas also in general.

(Paragraphs 22.4.6, 22.4.7 and 22.4.8)

(xiii) In order to fix proportion between long, medium and short staple cottons for the sake of a production programme, it is necessary to make a periodical review of the domestic as well as export demands. More of medium and short staple cottons may be required in future and suitable high yielding varieties have to be bred for the purpose.

(Paragraph 22.4.15)

(xiv) The results of practical utility already available should be fitted into suitable agronomic and plant protection practices in the different regions. The emphasis in future years should be to make every State tackle its own research and developmental problems with the involvement of the Agricultural University and Department of Agriculture. For purposes of inter-State consultation and cooperation the important cotton growing states can be formed into groups as follows :

(a) Punjab, Haryana, Rajasthan and Uttar Pradesh.
(b) West Bengal, Bihar and Orissa.
(c) Gujarat, Madhya Pradesh and Maharashtra.
(d) Karnataka, Andhra Pradesh and Tamil Nadu.

It is not sufficient if the Central Cotton Research Institute, Nagpur has few substations. It is more important that it also develops a working partnership for solving regional problems with the concerned agricultural universities.

(Paragraph 22.4.17)

(xv) Wherever feasible, adjustment of cropping season may be considered from the view point of insect or disease free period also on the same analogy as the 'Potato Seed Plot Technique'. Methods of biological control may be investigated, developed and popularised. Cooperative pest management practices involving the whole village approach should be encouraged.

(Paragraphs 22.4.18 and 22.4.19)

(xvi) Breeding work should also take into consideration some special requirements like (a) varieties which can withstand the effects of high soil moisture in high rainfall areas, (b) varieties for early sowing under such high rainfall conditions, (c) varieties with gossypol free seed, (d) increased oil percentage in seed without detriment to quality or quantity of lint and (e) varieties with fibre suitable for blending with synthetic fibres. Suitable combination of agronomic and plant protection schedules is also required to be developed for making the varieties yield their best in high rainfall areas. Developing varieties and agronomic and plant protection techniques for cotton cultivation during the months of December to April in West Bengal and the adjoining States of Bihar and Orissa should also engage attention.

(Paragraphs 22.4.19, 22.4.21 and 22.4.22)

(xvii) The Cotton Technological Laboratory should continue to study all facets of fibre quality and treatment which will promote the use of cotton varieties for blending purposes and incorporate easy care properties even in pure cottons.

(Paragraph 22.4.22)

(xviii) Bast fibres : The comparatively low price of jute and allied goods is an advantage which has to be maintained by continuous attention to productivity as this is the only way to save this crop from competition from other sources. New uses of jute and allied fibres such as textiles, flooring and construction materials, woollenised goods should receive constant attention. Woollenised goods in particular may have a great attraction in this country as well as other similar developing countries because of their low cost.

(Paragraph 22.5.5)

(xix) Developmental measures should be intensified in order to bring home to the farmer the full benefits of research work and provide him with all necessary inputs and extension agencies should be specially geared up for this

purpose. Extension agencies have to educate farmers that they can use the ideally stored seed up to two years rather than seeking renewal every year. Extension agencies should impress on farmers that well stored seed may be used upto two years and annual renewal is not necessary. This will relieve pressure on the demand for fresh seed and enable a larger coverage with the same amount of seed.

(Paragraph 22.5.16)

(xx) The most important problem that needs attention in the case of sannhemp is to break the barrier of self sterility and bring forth durable hybrids or synthetics. Another is the breeding of varieties separately for green manuring and for fibre purposes. The third important problem relates to a special seed multiplication programme to overcome deterioration caused by cross pollination.

(Paragraph 22.5.30)

(xxi) The Jute Agricultural Research Institute (JARI) and the Central Ramie Research Station, Sorbhog (Assam) should continue to be responsible for research work on ramie for the time being. It is necessary that the mesta and sannhemp growing States should themselves be made directly responsible for research work on these crops through the involvement of their agricultural universities. The JARI should play only a coordinating role. Insofar as agave is concerned, the basic work being done by the Bamra Substation of the JARI can continue as at present. The technological aspects relating to all these crops should be continued to be dealt with by the Jute Technological Laboratories for the country as a whole.

(Paragraphs 22.5.20, 22.5.24, 22.5.29 and 22.5.43)

(xxii) The minimum viable unit of agave plantation is 105 hectares. Such plantations should be organised on cooperative lines by small enterprising farmers. Because of the agronomic and decortication techniques involved, it will be a fit venture for agricultural graduates and preference should be given to them to establish agave plantations.

(Paragraph 22.5.40)

(xxiii) The ICAR institutions relating to agave should not directly involve themselves in multiplication programmes except for the supply of nucleus material. The State Governments concerned should have their own nursery stations with facilities to take up research work of an adaptive nature. The ICAR institutions should devote their attention mainly to research problems, wherein due emphasis has to be

given to breed varieties, which should give increased outturn, better quality of fibre and be at the same time resistant to pests and diseases. As seed-setting in agave requires a cool climate, the ICAR should choose a suitable station for this purpose at some higher altitude. Because the land which will be available for this crop will be mostly marginal or sub-marginal, improvement in its productivity should also engage attention in research programmes. Arrangements may have to be made for the exchange of knowhow on this crop from other countries advanced in the cultivation of this crop.

(Paragraphs 22.5.41 and 22.5.42)

(xxiv) The Central Arid Zone Research Institute at Jodhpur and the University of Udaipur or any agricultural university which may be established in Rajasthan should undertake the responsibility of research work for the propagation of agave in dry conditions.

(Paragraph 22.5.43)

APPENDIX 22.1—Oilseeds

(Paragraphs 22.1.1 and 22.3.1)

Statement I—Utilization of Oilseeds (Percentage of average production during the period 1963-64 to 1968-69)

Oilseeds	Export	Seed	Eaten as food	For oil extraction
groundnut	0.4	12.0	5.8	81.8
brassicas	..	1.5	5.8	92.7
sesamum	..	2.3	19.9	77.8
linseed	..	5.0	7.2	87.8
castorseed	..	5.7	..	94.3
safflower	..	5.6	5.1 4.3(a)	85.0
niger	..	7.0	18.0	75.0

(a) animal feed.

(Paragraph 22.1.1)

Statement II—Utilization of Oils As Percentage of Estimated Total Internal Utilisation During the Quinquennium ending 1967-68

Oil	For edible purpose	For vanaspati manufacture	Total edible	For non-edible purpose	Total
groundnut . . .	56.3	25.5	81.8	18.2	100.0
brassicas . . .	99.2	..	99.2	0.3	100.0
sesamum . . .	69.6	18.8	88.4	11.6	100.0
linseed	23.8	..	23.8	76.2	100.0
castor	..	..	..	100.0	100.0

Note :—Information on the use of safflower and niger oils is qualitative in nature. It is said that the oils are used chiefly for edible purpose, but there are other uses too to some minor extent, e.g. toilet, lighting, paints and soap.

Source :—1. 1771, Bulletin on Commercial Crop Statistics (1963-64 to 1968-69—First Issue, Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India.

2. 1767, Safflower—Bulletin No. 168 of Marketing Series, Directorate of Marketing & Inspection, Ministry of Agriculture, Government of India.

3. 1774, Niger—Bulletin No. 178 of Marketing Series, Directorate of Marketing & Inspection, Ministry of Agriculture, Government of India.

APPENDIX 22.1 (Contd.)

(Paragraph 22.1.4)

Statement III—Area and Production of Oilseeds Crops—State-wise and Crop-wise (1969-70 to 1971-72)

State	Area (% of all-India)	Production (% of all-India)	Yield q/ha	Area irrigated as % of total area (1969-70)
1	2	3	4	5
	1. Groundnut			
Gujarat	24.4	26.4	8.5	1.5
Maharashtra	12.2	10.0	6.4	1.8
Karnataka	12.0	10.7	6.9	..
Andhra Pradesh	20.2	19.9	7.7	12.5
Tamil Nadu	13.5	16.4	9.5	13.3
total.	82.3	83.4	..	..
Punjab	2.5	2.9	9.1	16.4
Rajasthan	3.0	2.4	6.1	3.4
Uttar Pradesh	4.6	4.0	6.8	0.3
Madhya Pradesh	6.2	5.2	6.4	..
Orissa	1.0	1.6	12.2	..
total	17.3	16.1	..	..
grand total	99.6	99.5	..	..
	2. Sesamum			
Rajasthan.	21.9	14.8	1.4	..
Uttar Pradesh	25.5	20.2	1.6	..
Madhya Pradesh	14.4	10.0	1.4	..
Bihar	1.3	2.0	3.2	..
Orissa	4.2	10.0	4.9	..
total	67.3	57.0	..	..
Gujarat	5.1	8.4	3.4	..
Maharashtra	6.2	7.1	2.4	..
Karnataka	3.1	4.5	3.0	..
Andhra Pradesh	10.3	9.5	1.9	..
Tamil Nadu	5.2	8.1	3.2	..
total	29.9	37.6	..	..
grand total	97.2	94.6	..	..

APPENDIX 22.1 (Contd.)

Statement III (Contd.)

State	Area (% of all-India)	Production (% of all-India)	Yield q/ha	Area irrigated as % of total area (1969-70)
1	2	3	4	5
	3. Niger			
Bihar	10.8	16.4	3.7	..
Orissa	15.0	27.5	4.4	..
Madhya Pradesh . .	49.3	37.3	1.8	..
Maharashtra . . .	16.6	11.7	1.7	..
total . . .	91.7	92.9	..	..
Karnataka . . .	5.4	3.9	1.7	..
Andhra Pradesh . .	2.9	3.2	2.6	..
total . . .	8.3	7.1	..	..
grand total . .	100.0	100.0	..	..
	4. Castor			
Gujarat	11.2	25.4	7.2	..
Madhya Pradesh . .	1.3	1.5	3.6	..
Bihar	1.1	1.4	4.0	..
Orissa	5.4	12.0	7.1	..
total . . .	19.0	40.3	..	..
Karnataka . . .	7.8	12.1	5.0	..
Andhra Pradesh . .	68.9	42.9	2.0	..
Tamil Nadu . . .	2.1	2.4	3.7	..
total . . .	78.8	57.4	..	..
grand total . .	97.8	97.7	..	..
	5. Brassicas			
Punjab	3.2	3.8	5.9	65.2
Haryana	4.1	5.2	6.2	30.0
Rajasthan	8.0	8.9	5.5	26.2
Uttar Pradesh . . .	64.8	65.6	5.0	2.1
Madhya Pradesh . .	5.9	3.8	3.2	3.8
Bihar	2.5	2.9	5.6	..
Orissa	1.7	1.6	4.7	..
West Bengal . . .	3.3	2.1	3.3	..
Assam Meghalaya Mizoram	4.2	3.5	4.2	..
total . . .	97.7	97.4	..	..

APPENDIX 22.1 (Contd.)

Statement III (Concld.)

State	Area (% of all-India)	Production (% of all India)	Yield q/ha	Area irrigated as % of total area (1969-70)
1	2	3	4	5
	6. Safflower			
Maharashtra . . .	64.6	73.1	2.7	..
Karnataka . . .	26.0	18.6	1.7	..
Andhra Pradesh . .	8.9	7.7	2.1	..
total . . .	99.5	99.4	..	..
	7. Linseed			
Uttar Pradesh . . .	40.5	40.3	2.6	..
Madhya Pradesh . .	32.6	30.2	2.4	..
Maharashtra . . .	11.2	8.5	2.0	..
total . . .	84.3	79.0	..	..
Rajasthan . . .	4.0	5.0	3.2	..
Bihar	3.5	6.7	5.0	..
Orissa	1.0	1.5	4.0	..
West Bengal . . .	2.2	2.4	2.9	..
Karnataka . . .	3.0	2.9	2.5	..
Andhra Pradesh . .	1.1	0.7	1.7	..
total . . .	14.8	19.2	..	..
grand total . .	99.1	98.2	..	..

Crop	Area (thousand ha)	Production (thousand tonnes)	Yield q/ha	Area irrigated as % of total area (1969-70)
	8. All India			
Groundnut	7,231	5,652*	7.8	5.4
Brassicas	3,361	1,663	5.0	8.0
Sesamum	2,383	490	2.1	..
Linseed	1,881	485	2.6	..
Safflower	589	142	2.4	..
Niger	483	116	2.4	..
Castor	419	134	3.4	..
	16,347	8,682		

*production relates to 'nuts in shell'.

APPENDIX 22.1 (Contd.)

(Paragraph 22.1.5)

Statement IV—Distribution of groundnut Districts(a) with Low or High Relative Yield Index(b) According to Different Rainfall Categories of South West Monsoon Season.

		A4/ A3	A2	A1	B4/ B3	B2	B1	C4/ C3	C2	C1	D4/ D3	D2	D1		Total
Punjab	RL(c)						..	..	..						6
	RH(d)						1	3	2						
Rajasthan	RL		1	1		5			2						9
	RH		..	..		..			..						
Uttar Pradesh	RL		2			5									12
	RH		..			5									
Madhya Pradesh	RL		4	2		4	1								14
	RH		..	1		1	1								
Orissa	RL		..		..										4
	RH		3		1										
Gujarat	RL		..	2			5			..					14
	RH		1	2			2			2					
Maharashtra	RL	..		1½		..	7	1	2½	1					19
	RH	1		..		2	2	½	..	½					
Karnataka	RL			..			1½	1	1½	..	..				12
	RH			1			..	1	1	4	1				
Andhra Pradesh	RL			1			..	2	..	2					16
	RH			1			3	3	1	3					
Tamil Nadu	RL										..	..	..		11
	RH								6	1	1	2	1		
total	RL	..	7	7½	..	14	14½	4	6	3	..	..	..	56	117
	RH	1	4	5	1	8	9	7½	10	10½	2	2	1	61	
% all-India area under each category		0.9	3.8	6.4	0.3	9.3	28.4	10.7	18.0	17.5	0.6	2.0	1.6		99.5

(a) Only those districts have been considered which have 10,000 ha or more under groundnut.
(b) Relative Yield Index—District crop yield expressed as % of all India.
(c) Relative Yield Index 90 or less.
(d) Relative Yield Index 91 or more.

APPENDIX 22.1 (Contd.)

(Paragraph 22.1.8)

Statement V—Distribution of Sesamum Districts(a) with Low or High Relative Yield Index(b) according to Different Rainfall Categories of South West Monsoon Season.

		A4/ A3	A2	A1	B4/ B3	B2	B1	C4/ C3	C2	C1	D4/ D3	D2	D1	Total
Rajasthan	RL(c)		1	2		4		..	5	2				18
	RH(d)		..	1		1		1	1	..				
Uttar Pradesh	RL		9		1	14	1	1						31
	RH		1		..	4	..	..						
Madhya Pradesh	RL		9			..	..							19
	RH		5			4	1							
Bihar	RL		..	..										6
	RH		5	1										
Orissa	RL		..		..									8
	RH		7		1									
Gujarat	RL	..		..		..	..			..				12
	RH	1		3		1	5			2				
Maharashtra	RL	..	1	..		1	..	1	..	..				20
	RH	2	..	2		1	8	½	2	1½				
Karnataka	RL						1	1	..	..	..			8
	RH						..	..	2	3	1			
Andhra Pradesh	RL			1	1		3	3	..	1				21
	RH			1	..		3	3	1	4				
Tamil Nadu	RL								..	..	..	..	..	11
	RH								6	1	1	2	1	
total	RL	..	20	3	2	19	5	6	5	3	..	..	..	63 } 154
	RH	3	18	8	1	11	17	4½	12	11½	2	2	1	91
% all-India area under each category		1.8	22.3	7.0	0.9	31.9	9.7	3.3	15.8	5.3	0.6	0.8	0.6	100.0

(a) Only those districts have been considered which have one thousand hectares or more under sesamum.
(b) Relative Yield Index = District crop yield expressed as % of all-India.
(c) RL = Relative Yield Index 90 or less.
(d) RH = Relative Yield Index 91 or more.

APPENDIX 22.1 (Contd.)

(Paragraph 22.1.19)

Statement VI—Area and Yield of Oilseeds—2000 AD

	Area (million hectares)		Yield (tonne/hectare)	
	Existing	2000 AD	Existing	2000 AD
groundnut	7.23	9.0	0.78	1.5
brassicas	3.36	4.0	0.50	1.0
sesamum	2.38	3.0	0.21	0.6
linseed	1.88	2.0	0.26	0.5
safflower	0.59	2.0	0.24	0.5
niger	0.48	1.5	0.24	0.5
castor	0.42	1.0	0.34	1.0
sunflower	..	2.0	..	1.0
soyabean	..	1.0	..	1.0
	16.34	25·5		

(Paragraph 22.1.19)

Statement VII—Production of Oil from Field Crops—2000 AD

(million tonnes)

Crop	Production (a)	Quantity of oilseed available for crushing		Oil recovery	
		% (b)	Quantity	% (c)	Quantity
groundnut	13.5	75	10.13	28	2.84
brassicas	4.0	93	3.72	33	1.23
sesamum	1.8	78	1.40	40	0.56
safflower	1.0	85	0.85	23(d)	0.20
niger	0.75	75	0.56	28	0.16
linseed	1.0	88	0.88	33	0.29
castor	1.0	94	0.94	37	0.35
sunflower	2.0	90(e)	1.80	40(e)	0.72
soyabean	1.0	50(e)	0.50	15(e)	0.07
	26.05				6.42

(a) Nuts in shell in the case of groundnut and seed in other cases.

(b) Please see Appendix 22.1—Statement II for crops other than sunflower and soyabean. In the case of groundnut, an additional provision of 7 per cent has been made for manufacturing groundnut milk. Therefore, the percentage availability of nuts for oil is taken as 75.

(c) 1973, Indian Agriculture in Brief, Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India, 12th Edition.

(d) Safflower oil recovery in reference (c) is given as 40%, but in Marketing Series Bulletin 168 of the Directorate of Marketing & Inspection, it has been mentioned as 23% only. The latter is adopted here.

(e) Assumed.

APPENDIX 22.1 (Contd.)

(Paragraph 22.1.19)

Statement VIII—Projections of Supply of oils obtained from By products of Field Crops, Plantation Crops and Oil Bearing Trees and Shrubs in 2000 AD

(million tonnes)

Commodity	Assumptions	Expected quantity of oil
1. cotton seed	cotton lint production according to moderate yield standards (alternative I as discussed under cotton)=4.32 million tonnes; seed=twice the lint; allowance for seed, feed and wastage=25% (permitting 10% cotton seed for animal feeding) oil recovery=15% of seed	0.97
2. rice bran	rice production =97.25 million tonnes; rice availability for bran=90%; bran recovery=5%; the quantity of bran available for oil extraction=80%; oil content; in bran=15% for raw and 20% for parboiled rice; parboiled rice=2/3 of total rice production	0.64
3. corn oil	Maize available for industrial utilisation (starch manufacture)=2.4 million tonnes, oil recovery =3%	0.07
4. bajra oil	provision for deoiled bajra for human consumption=1.50 million tonnes; deoiled bajra for animal feed=3.75 million tonnes ; deoiled bajra for industr. =1.50 million tonnes; oil recovery=4% . .	0.27
5. coconut oil (a)	production of coconut oil at present=30,000 tonnes; assumed to be double in 2000 AD	0.06
6. oil palm	proposed area=25,000 ha; oil yield=approx 2 tonnes	0.05
7. oil bearing trees and shrubs . . .	. . . .	1.20(b)
total . .	. . . .	3.26

(a) Bulletin on Commercial Crops Statistics, Directorate of Economics and Statistics, Ministry of Agriculture & Irrigation, New Delhi.

(b) Vide Chapter 43 on Minor Forest Produce.

APPENDIX 22.2—Oilseeds

(Paragraph 22.1.2)

Statement I—Some Important Research Problems

Nature of the problem or the objective	Research work: Already in an advanced stage	Research work: Initiated but needs to be intensified	Research work: Still to be started
1	2	3	4
a. Groundnut			
1. the formulation of the concept of plant type in groundnut specifically for : (i) monocropped rainfed areas (ii) multiple cropping (iii) summer irrigated cropping	..	..	X
2. the problem of drought resistance, tolerance or evasion	..	..	X
3. increased oil productivity per unit time and per unit area	..	X	..
4. introduction of seed dormancy in bunch types	..	X	..
5. resistance to tikka in bunch types	..	X	..
6. control of white grubs	..	..	X
7. increasing genetic variation for yield determining and oil characters through irradiation and hybridisation techniques	..	X	..
8. companion cropping of groundnut with cotton, bajra, red gram etc.	X	..	..
9. fertilizer response particularly with reference to phosphorus in the different groundnut regions	..	X	..
10. effects of calcium application at the pegging stage	..	X	..
11. effects of gypsum application as a soil amendment	X	..	..
12. effects of boron application to groundnut	X	..	..
13. effects of zinc application to groundnut	..	X	..
14. water requirement studies on the summer irrigated crop	..	X	..
15. physiology of sensitivity to water stress and different growth stages	..	..	X
16. studies on the effects of agronomic and plant protection practices on the oil content and quality	..	X	..
17. increasing the efficiency of rhizobial culture application in groundnut cultivation	..	..	X
18. study of the biogenesis of oil with particular reference to seasons and agronomic practices	..	X	..

APPENDIX 22.2—Statement I (Contd.)

1	2	3	4
19. developing varieties showing resistance to *Aspergillus flavus* or to aflatoxin production	..	X	..
20. survey of conditions of cultivation favouring aflatoxin production	..	X	..
21. seed dressing of groundnut kernels against soil and seed borne diseases and pests, to eliminate patchy stand	X	..	..
22. plant population density studies with reference to fertilization and use of implements in intercultural operations	..	X	..
23. developing suitable harvesting implements for groundnuts	..	X	..
24. developing groundnut pod drier . . .	..	..	X
25. developing a separate agronomy for seed production	..	..	X
26. developing plant protection schedules against :			
(i) collar rot	X	..	..
(ii) bud rot virus	..	..	X
(iii) rosettee virus	..	..	X
(iv) puccinia rust	..	X	..
b. Rapeseed & mustard			
27. developing the 'plant type' concept separately for :			
(i) multiple cropping (brown sarson raya)	..	..	X
(ii) mono-cropping (raya)	..	..	X
28. problem of drought resistance, tolerance or evasion	..	..	X
29. increased oil productivity per unit time, per unit area	..	X	..
30. evolving a toria variety of 80 days maturity for cropping before wheat	..	X	..
31. evolving brown sarson varieties for rainfed and frosty conditions	..	X	..
32. plant protection measures against :			
(i) aphids	X	..	..
(ii) alterneria	X	..	..
(iii) phyllody	..	..	X
33. plant population density and fertilizer studies on irrigated raya	..	X	..
34. studies on water requirement for raya and brown sarson	..	..	X
35. studies on the amount of nutrients utilized by one tonne yield of raya	..	..	X
36. evolution of synthetics in brown sarson and toria	..	X	..
37. evolving low erucic and high erucic types.	..	..	X

APPENDIX 22.2—Statement I (Contd.)

1	2	3	4
38. assessment of tolerance of *Eruca sativa* for drought and salinity	..	..	X
39. sulphur fertilization of rapeseed—mustard	..	X	..
40. canopy structure and plant geometry in raya	..	..	X
41. development of varietal blends in raya	..	X	..
42. exploitation of heterosis in raya	..	X	..
43. artificial synthesis of *B. juncea*	..	X	..
44. effect of minor elements particularly zinc on raya yields	..	X	..
45. induction of drought resistance by seed and plant treatments	..	..	X
46. detoxification of mustard cake through chemical and microbiological treatments	..	..	X
c. Sesamum			
47. development of "plant type" concept separately for :			
(i) mono-cropped rainfed areas (ii) mixed cropping (iii) multiple cropping (iv) irrigated *rabi* or summer cropping after paddy (v) semi arid cultivation in Rajasthan	..	X	..
48. problem of drought resistance, tolerance or evasion	..	..	X
49. increased oil production per unit time, per unit area	..	..	X
50. physiological distinctions between *kharif, rabi* and summer irrigated types	..	..	X
51. developing "hybrid sesame"	..	..	X
52. evolution of specific short duration, fertilizer responsive types for cultivation in succession to paddy in eastern coastal peninsular region	..	X	..
53. increasing oil content above 60%	..	..	X
54. decreasing oxalic acid content in the seed coat	..	..	X
55. plant protection measures against :			
(i) Xanthomonas	X	..	..
(ii) Pseudomonas	X	..	..
(iii) Macrophomina	..	X	..
(iv) Phyllody	..	..	X
(v) Antigastra	..	X	..
56. developing a decuticling machine for sesamum seeds to obtain seed cake for use in edible protein manufacture	..	X	..
57. companion cropping programme with other crops	..	..	X

APPENDIX 22.2—Statement I (Contd.)

1	2	3	4
d. Linseed			
58. developing "plant type" concept separately for :			
(i) alluvial regions (ii) peninsular regions (iii) ultra cultivation	..	..	X
59. problem of drought resistance, tolerance or evasion	..	..	X
60. increased oil production per unit time, per unit area	..	X	..
61. causes of low yield under ultra cultivation	..	..	X
62. incorporating wilt resistance into rust resistant types	..	X	..
63. evolving dual purpose linseed fibre varieties	..	..	X
64. plant protection against :			
(i) rust	X	..	..
(ii) wilt	..	X	..
(iii) leaf miner	..	..	X
65. evolution of linseed varieties with high iodine value . . .	..	X	..
66. problem of cyclic flowering and its removal	..	..	X
e. Castor			
67. developing the "plant type" concept in castor	..	..	X
68. problem of drought resistance tolerance or evasion	..	X	..
69. increased oil production per unit area, per unit time	..	X	..
70. exploitation of hybrid vigour . . .	X	..	..
71. isolation of 100% pistillate lines	..	X	..
72. early maturing varieties and hybrids of castor to evade end season drought and for use in multiple cropping	X	..	..
73. plant protection measures against :			
(i) semilooper	..	X	..
(ii) jassids	..	X	..
(iii) bacterial blight	..	..	X
74. cheap method of detoxifying castor cake	..	..	X
f. Safflower			
75. developing the "plant type" concept in safflower	..	..	X
76. problem of drought resistance tolerance or evasion	..	..	X
77. increased productivity of oil per unit area, per unit time	..	..	X
78. cultivation of safflower in soils with high pH	..	..	X

APPENDIX 22.2—Statement I (Contd.)

1	2	3	4
79. evolution of high yielding synthetics or composites	..	..	X
80. evolution of this hulled varieties with high oil content	..	..	X
81. methods of nirtogenous fertiliser application to obtain beneficial response . . .	..	X	..
82. effective machinery for dehulling safflower seeds	..	..	X
g. sunflower			
83. the "plant type" concept in sunflower (multi-headed or single-headed)	..	..	X
84. problems of drought resistance, tolerance or evasion	..	..	X
85. increased productivity of oil per unit area, per unit time	..	..	X
86. causes of bad filling of seeds in the central zone of heads	..	..	X
87. studies on insect pollinators and effects of beehives on yield and seed setting of sunflower	..	..	X
88. effects of moisture stress at different stages of growth	..	X	..
89. water requirement studies	..	X	..
90. studies on the amount of nutrients removed by one tonne of seed yield	..	..	X
91. developing a threshing machine	..	..	X
92. extent of linoleic and other unsaturated fatty acid contents in the oil of sunflower crops grown in the different seasons and region	..	..	X

APPENDIX 22.3—Tobacco

(Paragraph 22.3.1)

Statement I—Trend of Consumption of Tobacco Products in India

(thousand tonnes)

	1950-51	1960-61	1970-71
cigarette tobacco			
virginia flue cured	10	23	43
natu, Burley etc	10	19	29
total	20	42	72
bidi tobacco	52	73	84
chewing tobacco	50	62	51
hookah tobacco	54	43	28
cigar and cheroot	20	20	15.5
snuff	4	5	4.5
total tobacco	200	245	255

(Paragraph 22.3.3)

Statement II—Area, Production and Yield of Virginia and Other Tobaccos during 1940-41 to 1970-71

area = thousand ha
production = thousand tonnes
yield = tonnes/ha

Quinquennium ending	Virginia			Other than virginia			Total		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
1945-46 . .	42	32	0.76	316	282	0.89	358	314	0.88
1950-51 . .	55	39	0.71	286	221	0.77	341	260	0.76
1955-56 . .	74	53	0.72	281	204	0.73	355	257	0.72
1960-61 . .	87	65	0.75	306	227	0.74	393	292	0.74
1965-66 . .	108	84	0.78	301	254	0.84	409	338	0.83
1970-71 . .	149	103	0.69	284	251	0.88	433	354	0.82

APPENDIX 22.3 (Concld.)

(Paragraph 22.3.6)

Statement III—Area, Production and Yield and Percentage of Irrigated Area under Tobacco (average 1965-66 to 1971-72)

area = thousand hectares
production = thousand tonnes
yield = tonnes/hectares

State	Area		Production		Yield	Irrigated area as % of total area (1969-70)
	Actual	% of all-India	Actual	% of all-India		
1	2	3	4	5	6	7
Gujarat . . .	83.3	19.5	92.9	26.2	1.11	46.2
Maharashtra . .	13.7	3.2	6.3	1.8	0.46	8.3
Karnataka . . .	37.4	8.7	16.5	4.6	0.44	N.A.
Andhra Pradesh .	205.0	47.9	160.3	45.2	0.78	8.8
Tamil Nadu . .	14.1	3.3	20.8	5.8	1.47	62.1
total . .	353.5	82.7	296.8	83.6	0.84	
Rajasthan . . .	5.3	1.2	3.5	1.0	0.66	67.8
Uttar Pradesh . .	11.9	2.8	10.1	2.8	0.85	81.3
Madhya Pradesh .	2.6	0.6	1.3	0.4	0.50	71.4
Bihar . . .	13.9	3.3	12.6	3.5	0.91	21.6
Orissa . . .	13.1	3.1	9.1	2.6	0.69	..
West Bengal . .	13.4	3.1	11.1	3.1	0.83	..
Assam . . .	9.8	2.3	7.3	2.1	0.75	..
Tripura . . .	1.3	0.3	0.4	0.1	0.31	..
Other States . .	2.8	0.7	2.7	0.8	0.96	..
total . .	74.1	17.3	58.1	16.4	0.78	
all-India . . .	427.6		354.9		0.83	20.6

N.A.=Not Available.

APPENDIX 22.4—Cotton

(Paragraphs 22.4.2—22.4.6)

Area, Irrigation and Distribution of Districts (a) under Different Rainfall and Yield Ranges of Cotton (1968-69 to 1970-71)

State	Rainfall pattern	District	Percentage irrigated area (b)	Area under cotton (thousand hectares)	Cotton area as per cent of District gross cropped area	Cotton area as per cent of All-India Cotton area %(c)	RYI (d)
1	2	3	4	5	6	7	8
		A4/A3 (e)					
Gujarat	E4(A3B1)E4	Bulsar	2.0	17	5.3	0.22	144
		A2					
Gujarat	E4 (A2B1C1)E4	Surat	6.6	98	20.7	1.28	115
Madhya Pradesh	E4(A2C2)E4	Rajgarh	0.9	44	10.7	0.58	64
	E4(A2B1C1)E4	Hoshangabad	0.2	34	7.8	0.44	56
	E4(A2B1C1)E4	Sehore	0.3	12	2.5	0.16	40
Maharashtra	E4(A2B2)E4	Chanda	0.02	36	5.0	0.47	66
Rajasthan	E4(A2C2)E4	Jhalawar	0.2	23	7.0	0.30	71
		total		247		3.23	
		A1					
Madhya Pradesh	E4(A1B1C2)E4	Shajapur	0.4	69	18.6	0.90	66
	E4(A1B1C2)E4	Dewas	0.6	61	17.2	0.80	79
Maharashtra	E4(A1B1C2)E4	Wardha	0.5	177	40.5	2.31	42
	E4(A1B1C2)E4	Nagpur	1.3	86	15.4	1.12	65
Andhra Pradesh	E4(A1B1C2)D1E3	Adilabad	0.01	83	14.0	1.09	51
Gujarat	E4(A1B1C2)E4	Baroda	19.3	249	44.7	3.26	192
	E4(A1B1C2)E4	Broach	13.8	219	47.4	2.86	154
	E4(A1B1C1D1)E4	Sabarkantha	18.8	109	22.0	1.43	152
	E4(A1B1C2)E4	Kaira	7.6	64	11.1	0.84	160
	E4(A1B1C2)E4	Panch Mahals	6.1	28	5.3	0.37	150

Rajasthan	E4(A1B1C2)E4	Banswara	0.2	23	9.4	0.30	93
	E4(A1B1C1D1)E4	Chittor	55.4	21	5.2	0.27	100
		total		1,189		15.55	
		B2					
Madhya Pradesh	E4(B2C2)E4	Ujjain	0.3	59	12.4	0.77	55
	E4(B2C2)E4	Dhar	4.8	48	9.2	0.63	62
	E4(B2C2)E4	Ratlam	2.2	35	10.9	0.46	54
	E4(B2C2)E4	Jhabua	5.1	25	7.1	0.33	66
	E4(B2C1D1)E4	Mandsaur	4.8	15	2.5	0.20	56
Maharashtra	E4(B2C2)E4	Yeotmal	0.3	347	42.8	4.54	57
	E4(B2C2)E4	Nanded	0.4	210	27.8	2.75	55
Gujarat	E4(B2C2)E4	Banaskantha	20.6	22	2.4	0.29	150
Rajasthan	E4(B2C2)E4	Bhilwara	75.6	29	8.0	0.38	97
	E4(B2C2)E4	Udaipur	60.9	10	2.5	0.13	70
		total		800		10.46	
		B1					
Madhya Pradesh	E4(B1C3)E4	East Nimar	0.8	134	30.5	1.75	58
	E4(B1C3)E4	West Nimar	2.3	121	18.5	1.58	86
Maharashtra	E4(B1C3)E4	Amroati	0.07	367	50.9	4.80	55
	E4(B1C3)E4	Akola	0.1	338	42.1	4.42	45
	E4(B1C3)E4	Parbhani	0.3	272	27.2	3.56	47
	E4(B1C3)E4	Buldana	1.3	255	35.7	3.33	61
	E4(B1C3)E4	Jalgaon	2.3	250	29.3	3.27	67
	E4(B1C3)E4	Dhulia	7.2	75	10.0	0.98	70
	E4(B1C3)D1E3	Bhir	4.2	51	6.2	0.67	50
	E4(B1C3)D1E3	Osmanabad	0.1	47	4.2	0.61	56
Karnataka	D1E3(C2D2)C1E3 (B1C3)	Dharwar(f)	0.04	118	20.7	1.54	58
	E4(B1C3)D1E3	Bidar	Nil	13	3.2	0.17	52
Gujarat	E4(B1C1D2)E4	Surendranagar	7.0	296	42.9	3.87	85
	E4(B1C1D2)E4	Ahmedabad	8.6	208	33.1	2.72	125
	E4(B1C1D2)E4	Rajkot	44.3	80	10.4	1.05	156
	E4(B1C1D2)E4	Mehsana	22.2	67	8.6	0.88	204
	E4(B1C2D1)E4	Junagarh	47.3	33	5.2	0.43	201
	E4(B1C2D1)E4	Bhavnagar	30.2	32	5.1	0.42	153
	E4(B1C1D2)E4	Jamnagar	37.1	20	3.2	0.26	151

APPENDIX 22.4 (Concld.)

1	2	3	4	5	6	7	8
Haryana	E4(B1C2D1)E4	Karnal	97.4	15	1.8	0.20	161
		total		2,792		36.51	
Maharashtra	E4(C4)E4	Aurangabad	7.2	205	14.6	2.68	56
Karnataka	D1E3(C4)D1E3	Belgaum	13.2	119	12.3	1.56	44
	E4(C4)D1E3	Gulbarga	Nil	52	4.1	0.68	56
Andhra Pradesh	E4(C3D1)C1D1E2	Guntur	44.8	11	1.1	0.14	98
	E4(C3D1)D1E3	Mahboobnagar	0.7	11	1.0	0.14	27
Punjab	E4(C3D1)E4	Sangrur	97.9	39	6.1	0.51	258
	E4(C3D1)E4	Patiala	95.0	22	4.3	0.29	244
	E4(C3D1)E4	Ludhiana	99.0	19	4.0	0.25	275
Haryana	E4(C3D1)E4	Jind	99.7	15	4.4	0.20	159
Uttar Pradesh	E4(C3D1)E4	Aligarh	99.0	12	2.0	0.16	119
		total		505		6.62	
		C2					
Maharashtra	E4(C2D2)D1E3	Ahmednagar	24.7	27	2.0	0.35	92
Karnataka	D1E3(C2D2)C1E3 (B1C3)	Dharwar(f)	0.04	118	20.7	1.54	58
	E4(C2D2)D1E3	Bijapur	2.3	158	11.0	2.07	33
Punjab	E4(C2D1E1)E4	Ferozpur	99.2	155	14.9	2.03	337
	E4(C2D1E1)E4	Bhatinda	97.9	119	14.3	1.56	328
	E4(C2D1E1)E4	Amritsar	98.6	25	4.3	0.33	239
Haryana	E4(C2D1E1)E4	Hissar	99.7	154	10.5	2.01	293
	E4(C2D1E1)E4	Rohtak	98.0	11	1.6	0.14	172
Rajasthan	E4(C2D2)E4	Ajmer	85.0	12	2.8	0.16	109
		total		779		10.19	
		C1					
Maharashtra	E4(C1D3)D1E3	Sholapur	61.7	11	0.9	0.14	156
Karnataka	E4(C1D3)D1E3	Raichur	Nil	267	25.5	3.49	59
	D1E3(C1D3)D1E3	Bellary	0.8	113	18.7	1.48	60
	D1E3(C1D3)D1E3	Chitradurga	3.6	46	10.9	0.60	57

Andhra Pradesh	E4(C1D3)D1E3	Kurnool	0.3	144	12.6	1.88	37
	D1E3(C1D3)D1E3	Anantapur	0.9	33	3.6	0.43	34
Gujarat	E4(C1D1E2)E4	Kutch	26.0	45	7.5	0.59	177
	E4(C1D3)E4	Amreli	45.0	19	3.7	0.25	154
		total		678		8.86	
		D4/D3					
Tamil Nadu	D1E3(D4)B1C2D1	Tirunelveli	14.0	85	15.3	1.11	80
		D2					
Tamil Nadu	E4 (D2E2) E4	Ramanathapuram	18.1	75	11.6	0.98	74
	D2E2(D2E2) C2D1E1	Madurai	20.8	33	5.2	0.43	154
Rajasthan	E4 (D2E2) E4	Ganganagar	99.9	110	8.1	1.44	132
		total		218		2.85	
		D1					
Tamil Nadu	D2E2 (D1E3) C2E2	Coimbatore	56.3	95	11.7	1.24	286
		grand total		7,405			

(a) Districts considered in this statement are those which have an area of 10,000 ha or more under cotton.

(b) Data relate to the following years :—

Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Haryana, Punjab and Rajasthan } 1969-70
Madhya Pradesh 1971 72
Gujarat 1969-70
Tamil Nadu 1967 68

(c) Total average all-India area of cotton (1968-69—1970-71) is 7,648,000 ha. Total areas as given in column 5 will be less than this, because col. 5 relates to only such districts which have an area of 10,000 ha or more.

(d) RYI (Relative Yield Index)=District yields expressed as % of all-India. All-India average yield of cotton for 1968-69—1970-71=117 kg/ha.

(e) Such titles indicate highest category of rainfall in June-September period.

(f) A portion is under C2D2 and another portion of the district is under B1C3.

APPENDIX 22.5—Bast Fibres

(Paragraph 22.5.7)

Statement I—Area and Yield of Jute—1936-37 to 1971-72

Year	Undivided India area in thousand hectares				Indian Union area in thousand hectares			
	Actual	Departure from average	Per cent departure	Yield (tonnes/hectares)	Actual	Departure from average	Per cent departure	Yield (tonnes/hectares)
1	2	3	4	5	6	7	8	9
1936-37	1,168	—38	—3.1	1.43	NA			
1937-38	1,169	—37	—3.1	1.28	NA			
1938-39	1,281	+75	+6.2	0.92	NA			
average 1936-37 to 1938-39	1,206			1.21	349	..	..	0.95
1939-40	1,279	+96	+7.5	1.32	319	+12	+3.9	1.01
1940-41	2,294	+1,111	+93.9	1.00	510	+203	+66.1	0.94
1941-42	874	—309	—26.1	1.08	317	+10	+3.3	0.90
1942-43	1,349	+166	+14.0	1.16	343	+36	+11.7	0.83
1943-44	1,068	—115	—9.7	1.13	283	—24	—7.8	0.90
1944-45	851	—332	—28.1	1.26	235	—72	—23.5	0.86
1945-46	980	—203	—17.1	1.38	229	—78	—25.4	1.11
1946-47	773	—410	—34.6	1.22	217	—90	—29.3	1.05
average 1939-40 to 1946-47	1,183			1.19	307			0.95
1947-48	..	..	..	..	264	—147	—35.8	1.09
1948-49	..	..	..	..	338	—73	—17.8	1.05
1949-50	..	..	..	..	471	+60	+14.6	1.19
1950-51	..	..	..	..	571	+160	+38.9	1.04
average 1947-48 to 1950-51	..	..	..	..	411			1.09

1951-52	..	..	..	..	790	+115	+17.0	1.07
1952-53	..	..	..	..	734	+59	+8.7	1.13
1953-54	..	..	..	..	497	—178	—26.4	1.13
1954-55	..	..	..	..	503	—172	—25.5	1.06
1955-56	..	..	..	..	704	+29	+4.3	1.08
1956-57	..	..	..	..	772	+97	+14.4	1.01
1957-58	..	..	..	..	705	+30	+4.4	1.02
1958-59	..	..	..	..	733	+58	+8.6	1.28
1959-60	..	..	..	..	682	+7	+1.0	1.20
1960-61	..	..	..	..	629	—46	—6.8	1.18
average 1951-52 to 1960-61	..	..	..	..	675			1.12
1961-62	..	..	..	..	917	+119	+14.9	1.25
1962-63	..	..	..	..	847	+49	+6.1	1.16
1963-64	..	..	..	..	869	+44	+5.5	1.26
1964-65	..	..	..	..	845	+50	+6.3	1.29
1965-66	..	..	..	..	758	—40	—5.0	1.06
1966-67	..	..	..	..	797	—1	—0.1	1.21
1967-68	..	..	..	..	880	+82	+10.3	1.29
1968-69	..	..	..	..	527	—271	—33.9	1.00
1969-70	..	..	..	..	768	—30	—3.8	1.33
1970-71	..	..	..	..	749	—49	—6.1	1.19
1971-72	..	..	..	..	819	+21	+2.6	1.26
average 1961-62 to 1971-72	..	..	..	..	798			1.21
average 1961-62 to 1971-72 excluding 1968-69	..	..	..	..	825			1.23

APPENDIX 22.5 (Contd.)

(Paragraphs 22.5.9 & 22.5.10)

Statement II—Area, Irrigation and Distribution of Districts (a) under Different Rainfall and Yield Ranges of Jute (1969-70 to 1971-72)

State	Rainfall pattern			District	Area under Jute (thousand ha)	Jute area as per cent of			Notes
						District gross cropped area (b)	all-India jute area (c)	RYI (d)	
1	2			3	4	5	6	7	8
				(f)					
	(e)			A4					
West Bengal	E2C1A1	(A4)	C1E3	Cooch-Behar	52.9	14.3	6.0	90	(a) Districts considered in the statement are those which have an area of 1,000 ha or more under jute.
	E2C1A1	(A4)	C1E3	Jalpaiguri	41.3	10.6	5.3	97	
	E2C1B1	(A4)	C1E3	Darjeeling	3.3	2.6	0.4	94	
Assam	E2C1A1	(A4)	C1E3	Goalpara	35.3	6.5	4.5	124	
	E2C1A1	(A4)	C1E3	Garo Hills	6.4	6.8	0.8	116	
	D1C1B1A1	(A4)	C1E3	Lakhimpur	3.6	1.1	0.5	115	
				total	142.8		18.3		
				A3					(b) Averages of gross cropped area used for working out the percentages pertain to the period 1968-69 to 1970-71.
West Bengal	E3C1	(A3B1)	C1E3	West Dinajpur	64.1	9.4	8.2	76	
Tripura	E1D1C1A1	(A3B1)	C1E3	Tripura	8.2	2.2	1.1	110	
Assam	E1D1C1B1	(A3B1)	C1E3	Nowgong	37.1	10.8	4.8	108	
	E1D1C1A1	(A3B1)	D1E3	Kamrup	31.7	4.9	4.1	109	
	E1D1C1A1	(A3B1)	C1E3	Darrang	19.2	4.8	2.5	119	
	E1D1B2	(A3B1)	C1E3	Sibsagar	2.3	0.6	0.3	114	
				total	162.6		20.9		
				A2					(c) Total average all-India area of jute (1969-70 to 1971-72)
Bihar	E3C1	(A2B2)	D1E3	Purnea	102.8	10.1	13.2	63	
	E3D1	(A2B2)	D1E3	Champaran	6.5	0.4	0.8	97	

West Bengal	E2D1C1	(A2B2)	C1E3	24-Parganas	43.3	4.4	5.6	126
	E2D1C1	(A2B2)	C1E3	Hooghly	31.4	8.3	4.0	147
	E3C1	(A2B2)	C1E3	Malda	24.8	4.9	3.1	75
	E3C1	(A2B2)	C1E3	Midnapore	10.5	0.9	1.3	129
	E2D1C1	(A2B2)	C1E3	Howrah	4.6	3.2	0.6	144
Assam	E1C1A2	(A2B2)	C1D1E2	United Mikir & North Cachar Hills	1.4	1.5	0.2	113
Orissa	E3D1	(A2B2)	C1E3	Cuttack	35.1	3.4	4.5	108
	E2D1C1	(A2B2)	C1E3	Balasore	6.9	1.2	0.9	90
	E3D1	(A2B2)	C1E3	Keonjhar	2.0	0.5	0.3	98
	E3D1	(A2B2)	C1D1E2	Puri	1.3	0.2	0.2	101
			C1E3					
Uttar Pradesh	E4	(A2B1C1)	E4	Bahraich	2.1	0.4	0.3	113
				total A1	272.7		35.0	
Bihar	E3D1	(A1B3)	D1E3	Saharsa	22.8	4.1	2.9	69
	E3D1	(A1B2C1)	D1E3	Dharbhanga	2.9	0.4	0.3	96
				total B3	25.7		3.3	
Bihar	E3D1	(B3C1)	D1E3	Muzaffarpur	1.0	0.1	0.1	97
	E3C1	(B3C1)	C1E3/D1E3	Murshidabad	76.1	9.5	9.8	106
	E2D1C1	(B3C1)	D1E3	Nadia	69.9	10.5	9.0	109
	E3C1	(B3C1)	D1E3	Burdwan	11.7	1.8	1.5	138
				total B2	158.7		20.4	
Uttar Pradesh	E4	(B2C2)	E4	Kheri	5.6	0.9	0.7	113
	E4	(B2C1D1)	E4	Sitapur	2.5	0.4	0.3	113
				total	8.1		1.0	
				grand total	770.6		99.0	

used for calculations is 778.5 thousand hectares. Total area as given in column 5 will be less than this, because column 5 relates to only such districts which have an area of 1,000 ha or more.

(d) District yields expressed as % of all-India. All-India average yield of jute for 1969-70 to 1971-72 is 1.26 tonnes/ha.

(e) Rainfall symbols for the months of February-May have been purposely arranged in the sequence in which the months succeed each other. This does not necessarily hold good for the monsoon or post-monsoon months.

(f) Such titles indicate highest category of rainfall in June-September period.

APPENDIX 22.5 (Contd.)

(Paragraph 22.5.18)

Statement III—Area, Production and Yield of Mesta (1965-66 to 1971-72)

area = thousand hectares
production = thousand tonnes
yield = quintals/hectare

State	Area	Per cent of all-India	Production	Per cent of all-India	Yield
West Bengal . . .	61.1	19.1	60.6	28.7	9.92
Bihar . . .	35.1	11.0	26.6	12.6	7.58
Orissa . . .	25.1	7.9	20.8	9.9	8.29
Northeast region . .	20.8	6.5	17.4	8.2	8.37
total eastern parts . .	142.1	44.6	125.4	59.4	8.82
Andhra Pradesh . .	88.6	27.8	59.1	28.0	6.67
Maharashtra . .	49.7	15.6	15.0	7.1	3.02
Karnataka . . .	23.2	7.3	7.6	3.6	3.27
Madhya Pradesh . .	14.5	4.5	3.8	1.8	2.62
others . . .	0.8	0.3	0.2	0.2	..
all-India . . .	318.9		211.1		6.62

APPENDIX 22.5 (Contd.)

(Paragraph 22.5.26)

Statement IV—Area, Production and Yield of Sannhemp (1965-66 to 1971-72)

area = thousand hectares
production = thousand tonnes
yield = quintals/hectare

State	Area	Per cent of all-India	Production	Per cent of all-India	Yield
Uttar Pradesh	59.7	36.0	23.0	36.6	3.85
Madhya Pradesh	29.8	18.0	10.3	16.4	3.46
Maharashtra	21.5	13.0	6.2	9.9	2.88
Rajasthan	15.2	9.2	4.7	7.5	3.09
Bihar	7.8	4.7	3.8	6.0	4.87
Orissa	7.4	4.5	5.8	9.2	7.84
Andhra Pradesh	6.7	4.0	2.2	3.5	3.28
Karnataka	4.5	2.7	1.5	2.4	3.33
Punjab	4.4	2.7	1.2	1.9	2.73
Haryana	3.2	1.9	0.9	1.4	2.81
West Bengal	1.8	1.1	1.4	2.2	7.78
Gujarat	1.7	1.0	1.0	1.6	5.88
other States	2.0	1.2	0.9	1.4	..
all-India	165.7		62.9		3.80

APPENDIX 22.5 (Concld.)

(Paragraph 22.5.40)

Statement V—Cost of and Profit from One Unit of Sisal Plantation of 100 Hectares (a)

amount in thousand rupees
fibre yield in tonnes

	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	Total
A. recurring expenditure :											
(i) pay and allowances of staff	11.88	11.88	11 88	14.10	14.10	14.10	16.32	16.32	16.32	16.32	143.32
(ii) office contingencies	1.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	6.00
total office	13.38	12.38	12.38	14.60	14.60	14.60	16.82	16.82	16.82	16.82	149.22
(iii) farm contingencies	12.79	17.23	21.23	29.21	38.04	48.12	58.20	67.30	75.41	83.10	450.98
total	26.17	29.61	33.96	43.81	52.64	62.74	75.02	84.12	92.23	99.92	600.20
B. non-recurring expenditure	40.50	12.50	18.90	15.00	20.00	20.00	10.00	10.00	..	..	149.90
grand total	66.67	42.11	52.86	58.81	72.64	82.74	85.02	94.12	92.23	99.92	750.12
1. fibre yield	..	..	..	8.50	21.00	38.50	56.00	71.00	83.50	93.50	372.00
2. value of fibre	..	..	..	25.50	63.00	115.50	168.00	213.00	250.50	280.50	1116.00
3. value of suckers	..	..	5.00	10.00	15.00	20.00	25.00	25.00	25.00	25.00	150.00
4. value of bulbils (b)	..	..	..	..	..	..	..	..	..	250.00	250.00
Total 2, 3 and 4	..	..	5.00	35.50	78.00	135.50	193.00	238.00	275.50	555.50	1516.00
5. profit from :											
(i) fibre	—66.67	—42.11	—52.86	—33.31	9.64	32.76	83.98	118.88	158.27	190.58	365.88
(ii) fibre, suckers and bulbils	—66.67	—42.11	—47.86	—23.31	5.36	52.76	108.98	143.88	183.27	465.58	765.88

(a) Based on information furnished by the Study Team on jute and allied fibre crops.

(b) Bulbils @ 500,000 per hectare in the 10th year; value Rs. 25 per thousand.

APPENDIX 22.6

(Paragraph 22.6.1)

Area and Yield Targets of Various Commercial Crops—2000 AD

Crop	Area (Mha)		Yield (tonnes/ha)		Reference		
	Present	Targeted	Present	Targeted	Table	Appendix	Para-graph
groundnut	7.23	9.00	0.78	1.50	..	22.1 Stat. VI	22.1.7
sesamum	2.38	3.00	0.21	0.60	..	,,	22.1.8
niger	0.48	1.50	0.24	0.50	..	,,	22.1.9
castor	0.42	1.00	0.34	1.00	..	,,	22.1.10
brassicas	3.36	4.00	0.50	1.00	..	,,	22.1.11
linseed	1.88	2.00	0.26	0.50	..	,,	22.1.12
safflower	0.59	2.00	0.24	0.50	..	,,	22.1.13
soyabean	..	1.00	..	1.00	..	..	22.1.16
sunflower	..	2.00	..	1.00	..	..	22.1.18
sugarcane	2.59	5.00	49	82	..	..	22.2.10
sugarbeet	..	0.50	..	40	..	..	22.2.12
tobacco	0.45	0.55	0.83	1.50	..	..	22.3.17
cotton	7.60	11.50	0.12	0.46	22.7	..	22.4.9 22.4.11
jute	0.78	1.00	1.26	2.60	..	..	22.5.13 22.5.16
mesta	0.32	0.32	0.66	1.25	..	22.5 Stat. III	22.5.20
ramie	..	0.01	..	..	..	..	22.5.24
sannhemp	0.17	0.17	0.38	0.76	..	22.5 Stat. 1V	22.5.29
flax	..	0.005	..	..	..	..	22 5.32
agave	0.003	0 02	0.80	2.50	..	..	22.5.39
total area	28.253	44.575					

23

HORTICULTURAL CROPS

Various fruit, tuber, bulb and vegetable crops have been dealt with in this Chapter. Important crops like mango, banana, citrus, papaya, guava, apple, grape, pineapple, walnut, potato, sweet potato, tapioca, onion and garlic have been considered individually and the rest in a collective manner. In addition, there is an assortment of commodities which are added to vegetables in cooking or salad preparations and are grown with the same intensive care as vegetables proper. Some of these can be grouped under condiments and spices. Important among these are ginger, turmeric, chillies and coriander. Edible mushrooms are also utilized as vegetables. All of these have been dealt with in this Chapter. Crops under floriculture and aromatic and medicinal plants, which require comparatively small areas but intensive care have also been considered.

1 FRUIT CROPS

23.1.1 Fruits serve as a natural source of vitamins and minerals. These also supplement the carbohydrates and proteins to varying degrees depending upon their composition. One of the easiest and cheapest ways to fortify the average daily diet with vitamins and minerals and some of the essential amino-acids for millions of people in India could be to ensure a certain minimum level of intake of fruits in preference to medicated pills or tonics. A provision of 30 grams of fruits per day has been indicated in the 'improved diet at a moderate cost' in Appendices 9.9 to 9.12 of Chapter 9 on Nutrition. It has been emphasised in that Chapter that cultivation of less expensive but nutritive fruits should be encouraged and there was necessity for evolving high yielding and short duration varieties of the more common fruits.

23.1.2 According to land-use statistics published by the Directorate of Economics & Statistics, Ministry of Agriculture and Irrigation (DES), the area under fruits, fresh and dry, was 1.45 Mha in

1970-71. This estimate does not take into account the area under scattered trees and is, therefore, incomplete. It is estimated that the area under these crops would be of the order of 1.8 Mha at the end of the Fourth Five Year Plan. The target set for the Fifth Five Year Plan is 2.3 Mha. The estimated production of fruits at the end of the Fourth Five Year Plan is being put at 9.2 million tonnes and the target for the Fifth Plan has been fixed at 10.2 million tonnes. Assuming that the existing area is between 1.5 to 1.8 Mha and that it would be possible to raise it to two to two and a half times, the area under fruit crops would be of the order of 4 Mha in 2000 AD.

23.1.3 In our view, there is a possibility of doubling the present yield level of these crops by various developmental measures and as such their production could be pushed to more than four times of the existing level by 2000 AD. As such in our view, it is possible to step up the production of fruits by the turn of the century not merely to meet the rapidly rising internal demand but also to realise substantial exportable surpluses. The scope for stepping up exports of fruits has been broadly indicated in Chapter 12 on Export Possibilities and Import Substitution. The choice of fruits for exports has so far been confined only to a few major items like banana, mango, citrus and walnuts. It is necessary to diversify exports both in terms of items and destinations. The export demand for fresh fruits has to be considered together with demand for preserved and processed fruit products. In fact, through canning, pickling and the preparation of jams and jellies, various kinds of indigenous fruits, which might not have an appeal ordinarily in fresh form in foreign markets or which cannot stand a long transit owing to their perishable nature, have a very good chance of being accepted in other countries. As a necessary step to expand the country's export trade in fruits, a standard procedure may be evolved for the Indian Embassies to enable them to maintain a constant survey of the changing tastes and requirements abroad so that the production programmes within the country could periodically be given the required orientation. The processing aspects of fruits are considered separately in Chapter 57 on Processing and Agro-Industries. The future prospects of processed products are promising even within the country, particularly in defence establishments.

23.1.4 The extent of expansion of the cultivation of various fruit crops as envisaged here is such that it would require the backing of a well-organised multiplication and distribution programme of the planting material. Chapter 47 on Seeds deals with some of the important problems in this regard. It has been considered very necessary to establish a chain of progeny orchards from breeder to foundation and certified seed stages. It has been contemplated that the supervision and promotional measures with regard to progeny orchards

must be the responsibility of State Governments. It has also been suggested that detailed codes could be laid down within the purview of the Seeds Act to regulate multiplication and distribution of seed and planting material of fruit crops through progeny orchards.

23.1.5 A very serious problem which the fruit growers face is the menace of birds and monkeys. Round the clock vigil is usually maintained .for a good part of the day in season by employing human labour for the purpose of scaring them away, which adds up to the cost of production and reduces the margin of profit. Besides the quality of fruits is substantially impaired. In the case of birds, it is easy to develop electronic devices for raising alarm, but it has been found by experiments that the birds get accustomed to these and do not get influenced in the long run. Insofar as monkeys are concerned, there have been attempts to trap them and leave them further away. In practice, this is no solution. The potential for loss is merely transferred from one area to another and then it has been observed that these creatures are capable of returning to their old places without much time-lag. There is a feeling that laying baits for destruction is another way of preventing the loss to crops, but when viewed in terms of ecological balance, its disturbance in one direction has repercussions in creating an imbalance in some other direction. Even the problem of depredations as faced today is partly the result of creating an ecological imbalance by ruthless destruction of forests, because of which animals have been denied their natural habitat. Therefore, the long term and scientific solution really lies in restoring the natural balance. We have emphasised the need for afforestation in Chapter 42 on Production & Social Forestry and it is our hope that increased afforestation through various means in different areas would help in creating the required ecological balance. Alongside, the Indian Council of Agricultural Research (ICAR) could profitably consider a programme of research on the utility and maintenance of ecological balance so that necessary modifications could be made for time to time in order to make the plan of afforestation or other allied methods more effective.

23.1.6 In the context of the expansion programme of fruit cultivation, as also that of vegetables and other horticultural crops, a question that comes to the foreground is to create an effective official machinery to promote and organise the related activities. It has to be acknowledged that the States which have felt the necessity of separate Department of Horticulture, have already done so, e.g., Jammu & Kashmir, Uttar Pradesh, Himachal Pradesh and Karnataka. Other States can follow suit according to need. We do not desire to put forth the view that an identical pattern of developmental organisation must exist in

every State, but what we should like to emphasise is that the horticultural wing should be strong enough in every State. It should be left to the choice of the States concerned whether the subject should be handled by the Department of Agriculture or it should be looked after by an independent Department. If the effectiveness of the horticultural wing is ensured, the criticism that the set up is weak in many of the States at present would have been met to a very great extent.

23.1.7 The impact of ceiling laws on the size of fruit groves and orchards requires to be considered at this stage because it is an important factor which would exert an influence on the farmers' decisions to take to the cultivation of fruit crops. The guidelines drawn up on the basis of the conclusions of the Chief Ministers' Conference on Ceiling on Agricultural Holdings held on July 23, 1972, at New Delhi, indicated a land ceiling of not exceeding 54 arces (21.9 ha) for lands other than those having the facility of irrigation. It was laid down that the existing orchards might be treated as dry land and no additional allowance should be made for them. Banana plantations, guava gardens and vineyards were not to be treated as orchards. The States have framed their rules within this general framework. Assam Government has exempted large scale citrus cultivation in compact blocks exceeding 50 *bighas* (6.7 ha) as existing on January 1, 1955. The Jammu & Kashmir Government has exempted orchards subject to the payment of an annual tax. In Madhya Pradesh, an exemption has been given for land up to 5 acres (2.0 ha) used for orchards or mango groves forming a compact block of not less than such an area or as might be prescribed from time to time. In West Bengal, an extra allowance up to 2 ha has been made for orchards. But for exemptions like these, groves and orchards have to be treated within the usual ceiling. Because of this field crops and fruit crops would be competitive rather than complementary to each other. There lies a danger that farmers in general may not like to put in large part of their area under fruit crops, which would result in limiting the size of a grove or an orchard. It may even become necessary to make special efforts in future to induce the farmers to put at least a little part of their area under fruits. In order to be able to do so, a clear idea is required as to the minimum economic size of an orchard and also with regard to the comparative economics of raising a food or commercial crop as against a fruit crop. Another inducement, which could be thought of, is to provide extra assistance to the fruit growers in the form of special loans. Such assistance is very necessary to make them invest in a venture that starts giving income after a considerable time lag.

23.1.8 Fruit trees occupy area in the form of groves, orchards or

small clusters. Isolated trees are also found scattered in various kinds of situations including house compounds and along the roads and canals. Some fruit plants are cultivated like a field crop, e.g., banana, pineapple and strawberries. The DES publishes (a) area and production of banana and papaya and (b) area of mango, citrus, pome fruits, grapes and other fruits. Besides these major fruit crops, the country grows a very large variety of fruits. Appendix 23.1—Statement I gives the average annual exports of fruits from India during the period 1967-68 to 1971-72. Banana and mango are conspicuous items of export among fresh fruits. Exports of banana exceed those of mango in quantity, but in terms of value exports of both these items lie in the range of Rs. 25-30 lakhs. Exports of banana take place round the year, whereas those of mango are confined to its short fruiting season extending over 2-3 months. Walnut happens to account for about 70 per cent of the exports in value. It is desirable to concentrate attention on this dry fruit, which is already being exported to an appreciable extent as there is a good potentiality for extension of area under this crop. The export earnings from walnut can balance to some extent the imports of the other fruits. Appendix 23.1—Statement II shows that the fruits which are imported into the country are dates, grapes, raisins, pomegranates, almonds, pistachio-nut, apricots, oranges and some others. It might be mentioned that some of these fruits cannot be grown in appreciable quantities because of climatic difficulties.

Mango

23.1.9 Mango trees offer a common sight in the form of groves and orchards or in a scattered manner throughout the greater part of the country. Orchards of grafted mangoes are usually confined to such places where the produce can easily be marketed. It is reported that in Saharanpur and Varanasi districts of Uttar Pradesh seedling trees of inferior quality constitute as much as 50 to 70 per cent of the area under mango. This could be taken by and large to be equally true of the entire country. The groves of seedling mango are usually old and in a neglected state. The owners look after them only during the fruiting season. These groves are dwindling, because these are cut for wood at a faster rate than their replantation, specially in areas in the neighbourhood of plywood or packing case manufacturing units. It is seldom realised that seedling mangoes have their own place and preference in rural areas. Even in general, the fruit of seedling trees comes in the market later in the season and thus it helps to extend the season of availability of mango in the market

upto August. Therefore, this variety needs to be protected. Felling of seedling trees has to be so regulated that only decrepit trees are cut off and rate of felling should not outstrip that of replanting. It is important to maintain the correct proportion between removal and replenishment. Seedling mango crops have been neglected in research and developmental activities because of concentration of attention over the grafted ones. This imbalance should be corrected.

23.1.10 Rejuvenation of old orchards is included as one of the programmes of horticultural development in the Fifth Five Year Plan proposals in the State sector. A total area of 0.4 Mha comprising 0.3 Mha in the plains and 0.1 Mha in the hills is earmarked for such improvement. The assistance to be provided by way of credit is expected to be about Rs. 20 crores. The main crops for rejuvenation programme are mango and citrus, but the mango groves would naturally have a major share because of the extent of area under them. In the case of mango, methods of crown and side-grafting are already standardised. Trees of any age and size can be rejuvenated with superior scions, provided the bark is healthy and does not crack irregularly, when operated. The effective age limit from the viewpoint of economic returns is, however, about 30 years. The technique is popularly known as 'top-working', whereby a new scion top is made to utilise the extensive root system of a large old tree, which is required to be cut down above the trunk level. The old tree begins a new life with a better crown material, grows vigorously and has no difficulty in bearing fruits profusely or in having a long span of life. The method of top-working can be profitably applied to seedling mango trees of 30 years or less preferably in areas with easy communication links with market places. The object in general should be that the orchards of grafted mangoes preponderate in such areas which have easy marketing vantage, whereas the policy should be to plant seedling mangoes in the interior. Another way of improving the existing groves or orchards could be to interplant them with the new material of known pedigree and when the new trees come to fruiting stage, the old ones could be cut down. For top-working as well as ordinary grafting, it is necessary to train a large number of *malis* capable enough to perform custom service in budding and grafting. A vigorous extension programme will also be necessary to educate people to replace their inferior trees and groves.

23.1.11 The position of graft mango orchards is comparatively better, but even these require more attention. The area, both under seedling mango and the grafted mango needs to be doubled because of the importance of the fruit. Undoubtedly, the area increase will have to be thought of in various congenial regions throughout the

country. Community lands like those of the panchayats and the areas in the central plateau covering Madhya Pradesh, south Bihar and adjoining Orissa, which have been reclaimed from 'shifting cultivation', could be considered in this context. There was a time when seedling mango trees were a common sight along highways, but the preference now is for timber trees like *sisam* (*Dalbergia sisso*). It is worth making experimental trials on the comparative merits of planting road and canal sides with mangoes and other kinds of trees in order to determine feasibility and proportion of various interplants.

23.1.12 On research side, the problems which have not been fully solved as yet and, therefore, have been impeding improvement are those relating to the biennial bearing and malformation of the vegetative and floral shoots. These are considered below :

(i) Biennial bearing : Almost all the popular commercial varieties except *neelum, bangalora* and *rumani* of South India, are prone to the phenomenon of biennial bearing. These varieties are, however, poor in fruit quality. On the other hand, the north Indian varieties, which have excellent fruit quality, are not regular in bearing. Modern hybridization techniques have opened up a ray of hope and a hybrid between *neelum* and *dashehri* called *mallika* has already been evolved, which has an increasing tendency towards regular bearing. This approach requires to be tenaciously pursued until it becomes possible to release a good number of hybrids capable of bearing annually.

(ii) Malformation : No problem on mango has received so much attention as mango malformation which if left unchecked would wipe out the mango industry in the north. Fortunately, its incidence in the south is negligible at present. This malady is attributed mainly to a fungus, *Fusarium moniliforme*. Auxin imbalance within the plant is also suggested as a possible cause. Spraying with NAA (naphthalene acetic acid) has given some cure, though not on a consistent basis. However, basic control or elimination of the disease is still not in sight and, therefore, continuous research efforts are still needed.

23.1.13 It may be surprising to note that, even for such a popular crop, the real scientifically proven varieties are very few. All the plants giving similar fruit characteristics are generally grouped under a variety, e.g., *langra*, but the clones may vary in relation to productivity, disease-resistance, adaptability, quality and flavour, e.g., *Bihari langra* and *Banarasi langra*. Almost all Indian varieties are the results of local selection made during several centuries. Proper screening of

varieties is, however, very necessary. Many stations under the All India Coordinated Project on Fruit Improvement are collecting germ plasm. Systematic search should be made for high yielding quality clones of choice commercial varieties in all parts of India for building up nucleus material for further production of uniform and reliable planting material. Use of polyembryonic rootstocks would further ensure uniform performance in future plantations. These steps will enable introduction of genetic uniformity in the plants and increase production in a short time.

23.1.14 Breeding efforts have also to go on alongside for evolving newer and better varieties. The introduction of annual bearing as a stable character has already been emphasised earlier. Dwarfness in plants is considered to be a very desirable characteristic these days. Some polyembryonic varieties like *Vellai Kolumban* and *Olour* have shown promise as dwarfing rootstocks. Use of such rootstocks should be standardised to ensure dwarf plants enabling higher plant density and production besides better management of orchards. Building up of genetic resistance to pests and diseases and introduction of different maturity periods are some other lines of work. Certain mango cultivars like *langra, dashehri* and *chausa* show profound self-incompatibility which would considerably facilitate the breeding programmes, as a large number of crosses can be made within a year without resort to the process of emasculation. Along with the programme of rejuvenation, suitable agronomic techniques will have to be developed and recommended for adoption in different agro-climatic regions. It is necessary to ensure that research on seedling mangoes is given the needed attention.

Banana

23.1.15 Edible banana varieties belong to genis Musa and have originated from the wild progenitors *Musa acuminata* and *Musa balbisiana*. The latter species is comparatively more resistant to drought and many diseases. Most of the prevailing commercial varieties belong to *M. balbisiana* stock. *M. acuminata* gives fruits of better quality and the exportable cavendish varieties belong to this group. The harvesting period of banana is July-December. The crop is also harvested between December and April in Andhra Pradesh (East Godavari), September and March in parts of Karnataka and April and June in parts of Tamil Nadu and Karnataka. With the availability of quick means of transport, the fruit becomes available to almost every part of the country throughout the year. Cold climate and ill-drained soils do not suit this plant. Heavy rains, strong winds and drought also interfere

adversely with the regular seasonal pattern of its growth.

23.1.16 The statewise data on area, production and yield of banana are presented in Appendix 23.1—Statement III. The following points are significant :—

(i) About 75 per cent of area and production are in the peninsula and 20 per cent in the eastern parts (Orissa, West Bengal and north-eastern States). Kerala, Tamil Nadu and Maharashtra together account for about 60 per cent of the country's total area and production of banana.

(ii) Though the area is maximum in Kerala, the yield is poor, being only about 8 tonnes/ha. One of the reasons is the large area under low yielding variety, *nendran*. Tamil Nadu records an average yield of 18 tonnes/ha, whereas Gujarat and Maharashtra are the best with yields ranging between 20 and 25 tonnes/ha.

In Tamil Nadu, banana cultivation forms part of the crop rotation in well-drained wet lands in many paddy growing areas, and there is a tradition of applying higher doses of manures and fertilisers. In Maharashtra and Gujarat, the cavendish variety is grown in contiguous areas on intensive scale in Jalgaon and Bardoli districts respectively. Jalgaon district alone has more than 30,000 ha under cavendish bananas. In Bardoli, the area is reported to be 10,000 ha. There are 18 cooperative fruit marketing societies in Bardoli and 22 in Jalgaon and these societies control about 40 per cent of the production. They meet the input requirements and arrange for the marketing. The societies in Gujarat have formed a federation viz. the Gujarat State Cooperative Fruits and Vegetable Marketing Federation and the societies in Jalgaon have formed the Jalgaon District Fruit Sale Societies Federation. These two federations have jointly organised export of bananas to Gulf countries. The bulk of the banana grown in Gujarat and Maharashtra is marketed in Delhi and other upcountry markets. The intensive cultivation of banana backed by strong cooperatives is an important factor responsible for higher yields. In Kerala, the bunchy top disease takes a heavy toll of the crop. Moreover, a variety, *nendran,* which is also called as French plantain in many parts of the world, is widely grown in this State. It is a low yielder but it is preferred because a variety of products can be prepared from it and its fine flesh, which becomes soft in cooking.

23.1.17 The average quantity of banana exported was 10 thousand tonnes in 1968-69. In the subsequent years, the exports of bananas have tended to decline considerably. It does not reflect well that, out of a total production of about 3.2 million tonnes, only a negligible quantity should be of exportable standards. Efforts to push

the country's banana produce in the USSR and Japanese markets have not met with success on quality considerations. Concerted efforts on scientific lines with a view to bringing about all-round improvement of the crop are lacking. With an eye on profits, the attempt has been to get more yield by increasing the plant population per unit area and then sort out by grading fruits fit for export. A recent development, which can alter this position, is that the Government of India has become a major shareholder in the reorganised Banana and Fruit Development Corporation Limited, which was formed in 1964-65 by the Governments of Tamil Nadu, Andhra Pradesh, Kerala and Karnataka to promote cultivation and marketing including export of bananas. The Government of Orissa has also become a member and the Governments of Gujarat, Maharashtra, West Bengal and Union territory of Goa, Daman & Diu are expected to follow suit. With the involvement of the Government of India, it should be possible to bring about considerable improvement provided the entire chain of activities commencing from planting to post-harvest operations are placed on a sound scientific base for the whole banana area. It should be noted that the crop deserves full attention not only because of export demand, which is not expected to rise very high, but also to meet the internal demand for a variety of purposes. The pseudostem (central white core of the trunk), the inflorescence and unripe fruits are used as vegetables. Even the rhizone is cooked and eaten. The ripe fruit, though predominantly carbohydrate, contains useful minerals and vitamins. Its cost is within the reach of a common man and it is available almost throughout the year over most parts of the country. The need for supplementing cereal diet with potato, sweet potato and tapioca has already been stressed elsewhere. This fruit can also serve similar purpose. We, therefore, recommend that efforts should be made to increase area under banana considerably. The strategy should be to make its cultivation widespread with preference to small scale production.

23.1.18 All the banana growing States have their own units for research on this fruit. The Indian Horticultural Research Institute (IHRI) also started in 1968 a comprehensive research programme for banana improvement under which special attention is given to the exportable varieties. The studies include investigations on the effect of planting distances and NPK manurial doses on yield and quality of cavendish bananas (Dwarf and Robusta), improvement by breeding and selection, chemical weed control in banana groves, leaf analysis for establishing the critical level of major nutrients for obtaining maximum yields as well as the pre and post-harvest physiology of fruits. In the case of this crop, package of practices right from preparatory

tillage to harvesting have been developed for different regions and different situations like plains and hills. During the Fifth Five Year Plan period, it is proposed to popularise a package of improved practices in selected areas to increase the production of exportable varieties. However, it is necessary to extend this effort to all banana growing areas on the lines indicated by us to meet the rising internal demand. The research base for this crop is satisfactory and the aim must be an all-round improvement in cooperation with the agricultural universities of the regions concerned. The problems which need attention are mentioned below :

(i) Spacing of plants : It has been found that dense plant population results in undesirable effects such as octopus hands or twisted fingers, lesser weight of hands and rotting at neck. In some foreign countries, spacing adopted for cavendish varieties ranges from 1,500 to 2,000 plants per ha while in Maharashtra and parts of Tamil Nadu, it ranges from 3,750 to 5,000. The average quality and yield in Equador and Costa Rica are much superior despite thinner spacing. A systematic study is necessary with reference to experience in other countries.

(ii) Ratooning : The exportable varieties of bananas are taken as annual crops, while second and sometimes third ratoons are taken in the case of *Poovan, Monthan* etc., for internal consumption but the ratoon yields are poor. The minimum life of the stand in some foreign countries is 3 years though in Equador and Costa Rica, it extends even up to 10 years. Regular trials should be conducted to see how best and how many ratoon crops can give economic returns comparable with an annual crop.

(iii) Intercropping : In some parts of the country, other short duration crops are taken by way of intercropping in banana fields. Some of these crops appear to compete with the main banana crop and arrest its growth and prolong the maturity period. It is necessary to work out in detail the agronomic and economic aspects of intercropping in bananas. Studies should be conducted on the economics of underplanting banana in coconut groves.

(iv) Diseases and pests: Among the different pests and diseases, the incidence is very heavy in the case of wilt, bunchy top, leaf diseases, banana weevil and nematodes. Bunchy top has evaded solution till now, but efforts have to continue until some tangible results are obtained. In the case of leaf diseases, leaf spot (Sigatoka) is quite acute in

many parts of Tamil Nadu, especially in cavendish varieties. It will be worthwhile to have a special programme for evolving remedial measures. If a cheap oil based fungicide could be formulated, it will be easier to persuade the cultivators to adopt regular spraying. The problem of nematodes has received considerable attention in foreign countries. No work has been done in this country so far. If ratooning is going to be a normal feature of banana cultivation, it will all the more be necessary to ensure that the soil is free from nematode infestation.

(v) Water requirement : In view of the heavy requirements of water for banana cultivation, research on proper techniques of irrigation, which can economise the use of water should receive priority.

(vi) Other aspects requiring further research include harvesting techniques and techniques for protection of the banana bunches from external injuries, insect bites, sunburns etc.

23.1.19 There are some known results of researches already available which could be put into practice with advantage. These are mentioned below :

(i) There are some indications that the spacing of banana plants 2m×2m, cutting the first and last hands after emergence of all hands and tying the bunch with the stem in a perpendicular fashion can remove certain deformities of the 'fingers'.

(ii) In Kerala and other areas where 'bunchy top' disease is devastating, a complete replanting programme with healthy disease free suckers would minimise its incidence. In areas, where the disease is not serious, a package of practices emphasising timely roguing and application of insecticides to control the vector population could prove useful.

With the measures outlined above, it would be possible to double the existing yield standards leading to ample banana production in the country to meet the increasing internal demand and spare sizeable quantity for export.

Citrus

23.1.20 The area under citrus fruits in the country may be put at 0.1 Mha. There are various kinds of citrus fruits, which are grown and consumed more or less in every part of the country. The fruits have a special place in Indian diet because of the presence of vitamin C. Selected information regarding various citrus fruits is given in Table 23.1. About 40 per cent of the citrus area is occupied by

mandarins and 25 per cent each by the sweet oranges and limes. Citrus is known to suffer from certain disorders, which adversely affect growth and vigour resulting in drying of twigs and branches leading to gradual death of the whole tree. Sometimes healthy looking trees suddenly wilt. This malady known as citrus 'decline' or 'die-back' is highly pronounced in India when compared with other countries and, therefore, the yield is also comparatively lower. The citrus groves and orchards are not receiving the attention needed to get high yields. Major manurial ingredients like NPK are rarely applied to optimal extent and various necessary micronutrients like boron, calcium, copper, iron, magnesium, manganese and zinc are never applied at all. The orchards are laid without regard to soil pH. Tillage is either altogether absent or, when practised, it is done in excess causing root injury and infection. Irrigation is also often a limiting factor. Among the fungal diseases, organisms such as *Phytophthora sp.*, *Diplodia sp.* and *Fusarium sp.* causing root rot and stump rot have been reported in all citrus growing regions in India. Other diseases like powdery mildew (*Oidium sp.*), withertip (*Colletotrichum sp.*) and *Curvularia sp.* have been reported to cause chlorosis and twig drying. Among the insect pests, stem borers, top shoot borers, leaf miners, scales, mites, citrus psylla and aphids cause damage. In recent years, virus diseases like tristeza, greening, psorosis, exocorties, stubborn, xyloporosis have also been reported to be associated with the poor stand of citrus trees. Die-back disease is now recognised as a syndrome of various contributing factors like unfavourable soil conditions, improper orchard management, malnutrition, fungal and viral diseases, nematodes and stionic incompatibility (i.e., the mutual non-acceptance of the scion and stocks, because of which grafts decline or die).

23.1.21 A full understanding of the die-back malady has been a challenge to the scientists. Therefore, research work on these lines needs no emphasis. However, the malady has to be combated effectively in the country so that the loss to production gets minimised. Following are some of the suggestions which deserve consideration :

(i) It is now acknowledged that the incompatibility of scion and stock in citrus grafts can be an important primary cause for failures. Therefore, it is necessary to find out the most suitable stocks for different varieties of citrus in different regions.

(ii) There is need for evolving nucellar line plant material and establishing progeny orchards of nucellar lines for future budwood source for commercial varieties in every tract.

(iii) There is also need for intensifying the programme for certification, inspection and registration of virus-free mother trees and propagating and multiplying such virus-free trees

TABLE 23.1

Selected Information on Various Citrus Fruits

Type	Botanical name	Distinguishing characters	Major growing areas	Per cent of total citrus area* (1961-62)
mandarin (orange)	*Citrus reticulata*	loose skinned to varying degrees, segments easily removable, sour to varying degrees	Vidarbha (Nagpur orange) Coorg (Coorg orange) Khasi (Assam orange)	41
sweet orange	*Citrus sinensis*	tight skinned, segments more firmly set than in orange, sweeter than orange	Punjab (*Malta*) Marathawada (*Poona mosambi*) Andhra Pradesh (*Batavia, Satgudi*) Tamil Nadu	23
lime	*Citrus aurantifolie*	fruit oval of the size of a ping-pong ball, yellow in colour, acidic	Uttar Pradesh Andhra Pradesh	27
lemon (*galgal*)	*Citrus limon*	fruit oblong, bigger than lime, yellow	Assam, West Bengal, Bihar	5
others	*Citrus paradisi* (grape fruit), *Citrus grandis* (pummelo) etc.	—	—	4

*Estimates framed by Directorate of Marketing and Inspection, Ministry of Agriculture and Irrigation, Government of India, (DMI).

under foundation blocks for future sources of virus-free healthy budwoods.

(iv) Hybridization work in citrus should be taken up with the object of evolving rootstock varieties resistant to root rot disease and viruses, saline conditions and nematodes.

(v) Cultural Practices for commercial varieties need standardization. Only such intercrops have to be recommended which are experimentally proved to be harmless to citrus.

(vi) Studies are required to be undertaken to understand symptoms of deficiencies and excesses of various essential elements as also of the optimum fertilizer requirements of commercial varieties on different rootstocks.

(vii) Studies may be initiated to find out the biochemical changes, which occur in virus infected or die-back affected plants. Such studies might lead to chemotherapeutic measures against citrus infections.

(viii) Virus indexing programme and screening all the available citrus species and varieties for their resistance to various viruses and also screening for resistance to root rot diseases, nematodes need to be taken up.

(ix) The virus-vector relationship and sterilizing the vectors by irradiation technique need study in order to check the spread of the vector transmitted viruses.

(x) Research work may be taken up to induce resistance against severe strains of known viruses on citrus by cross protection with mild strains. This has been found possible in cacao and studies in progress on lime against tristeza virus at Bangalore appear to be quite promising.

23.1.22 In order to resuscitate the existing citrus orchards, scientists have drawn up various packages of practices for different agro-climatic regions of the country relevant to the preponderant symptoms typical of respective regions. The Fifth Five Year Plan programmes include 460 demonstration plots of 0.2 ha each to popularise high density planting and 1,710 demonstrations of 0.2 ha each for showing the efficacy of rejuvenation techniques. This kind of approach is only a partial solution, because the underlying idea in it is only to improve the existing plantations, which are mostly substandard. The real solution lies in a total replanting. It would have been ideal if grafts from mutually compatible scions and stocks were available for replanting but as their production is going to be a long range problem, a beginning could be made with the best available material as an immediate measure. Whereas there is a good scope to increase the area under this crop and, therefore, start orchards in new sites, there is also an imperative need to encourage interplanting of the existing orchards with

better grafted plant material with a view to ultimately cutting down the old trees.

Papaya

23.1.23 This plant is grown in many parts of the country in homesteads, gardens or even as a regular crop. Vegetable growers (*kachhis*) in the suburban areas always plant it, interspersed in their plots, along the bunds and irrigation channels. The fruit is available in the market for a major part of the year. There is a wide divergence in the area statistics of the DMI (1961-62) and DES (1968-69 to 1970-71). The total area might be estimated to range between 10 and 15 thousand hectares. A broad grouping of States areawise can be done in the following manner :—

(i)	Assam, West Bengal, Kerala, Maharashtra, Gujarat, Uttar Pradesh	10—30% of total area under the crop
(ii)	Madhya Pradesh, Bihar, Orissa	5—10% of total area under the crop
(iii)	Other States	less than 5% of total area under the crop

In Maharashtra and Gujarat, some pharmaceutical companies have taken initiative to encourage tapping of papain from papaya, but the practice has not yet assumed any commercial scale.

23.1.24 Papaya is one of the few fruit plants which is propagated by seed and vegetative propagation does not seem possible in its case. At the same time, the dioecious nature of the plant, the existence of many sex forms and their changing nature make the evolution of stable cultivars very difficult. The latest research work throws a ray of hope inasmuch as any desirable dioecious cultivar can now be converted to gynodioecism with complete elimination of males. This can be accomplished by initially pollinating the female with good hermaphrodites followed by back crossing until the desired characteristics have been restored. This technique requires to be followed in order to breed stable cultivars. Alongside, attempts have to be continued to find out a simple field test to identify sex in papaya seedlings at nursery stage so that unwanted male plants can be spotted out successfully in order to eliminate unproductive plant population from the field. Other desirable characteristics to be attempted for are dwarfness with ability to bear fruits at low heights, high yield of fruit and papain per tree, uniformity of shape, size, texture and flavour.

23.1.25 Papaya is seriously attacked by diseases but not by pests. The young seedlings in the nursery beds are quite often damaged by a fungus causing 'damping off'. As the disease is soil borne, the seed-

beds should be sterilised by steam or formalin before planting. Proper drainage should also be maintained. There is another disease known as 'collar or foot rot', in which the collar portion of the stem gets damaged and the whole plant dies afterwards. Scraping of the affected part and smearing coaltar, bordeaux paste and dilute carbolic acid have not met with any success. Prevention of water stagnation in the rooting zone is a good preventive measure, but an effective cure to this disease needs to be found out. Three virus diseases, viz., mosaic, leaf curl and distortion ringspot also severely affect this crop. It is feared that, with increased incidence of these viruses, growing of papaya may be rendered more difficult. No cure is in sight and, therefore, preventive measures such as destruction of affected plants and control of aphids by insecticidal spray have to be effectively popularised. The crop is also susceptible to frost. It is necessary that breeding programmes aim at incorporating resistance to viruses and frost.

Guava

23.1.26 It is perhaps least realised that guava and apple have more or less identical utility in nutrition. Additionally, guava is a rich source of vitamin C. A comparative idea of the compositions[1] of the two fruits is given below :

		composition (per 100 g)	
		guava	apple
edible portion	%	100	90
protein	gm	0.9	0.2
fat	gm	0.3	0.5
minerals	gm	0.7	0.3
fibre	gm	5.2	1.0
carbohydrate	gm	11.2	13.4
calcium	mg	10	10
phosphorus	mg	28	14
iron	mg	1.4	1
vitamin C.	mg	212	1

23.1.27 As against apple which is a temperate fruit requiring exacting cultivation practices, guava cultivation is found stretched over many agro-climatic regions covering the plains and plateau regions of the country. It can adjust to all types of soils and it is considered fairly drought resistant. The main concentration occurs in Uttar Pradesh, Bihar, Madhya Pradesh and Maharashtra the four States being

1 1971, Gopalan C. et al., Nutritive Value of Indian Foods : pages 86-88. Hyderabad. National Institute of Nutrition, Indian Council of Medical Research.

responsible for about 80 per cent of the area and production. Contribution of Uttar Pradesh alone exceeds 40 per cent. Flowering and fruiting processes in guava continue to some extent throughout the year in any place, but there are two distinct seasons when the bearing is comparatively more profuse, viz., rainy season and winter season.

23.1.28 Both guava and apple are useful and their cultivation can be fitted in a complementary manner. In fact, if one considers the cost factor, guava has an edge over apple. Secondly, the period of availability is also in favour of guava. It is desirable to encourage the cultivation of guava in as many congenial situations as possible. The tree is so adjustable that it can grow in homesteads very conveniently. Its plant on ravines and community lands under Panchayats etc. besides regular orchards should be encouraged. In order to produce quality fruits, certain points which need attention are mentioned below :

(i) A major constraint in guava production, viz., propagation through seed has now been removed, as various vegetative methods have been found to be successful. This aspect has been mentioned in Chapter 47 on Seed.

(ii) Experiments are needed to identify the best of the fruiting seasons in a year for every region of the country from the viewpoint of quality and quantity. Proper nutritional and irrigational standards have also to be established.

(iii) There are no serious pest and disease problems for this crop but for wilt. The wilt disease of guava is reported to be caused by three fungi, viz., *Fusarium solani* in regions of high soil moisture, *Fusarium oxysporium f. Psidii* in the region of moderate soil moisture and *Macrophomina phaseoli* in dry soils. The disease is soil borne. Therefore, the use of resistant rootstock is the only solution. Many cultivars are reported to be tolerant, but this view is very deceptive, because plant grows healthy for many years and no sign of disease is observed, but suddenly it starts wilting and dies within a few months. Unless resistance is proved pathogenitically, no cultivar should be taken as resistant or tolerant, even if it might have been growing unaffected for many years.

Apple

23.1.29 The fruiting season of apple commences in the west Uttar Pradesh hills in the first week of June, in Himachal Pradesh a fortnight later and in Kashmir valley after another fortnight. The seasonal supplies reach the market latest upto early November and whatever is sold thereafter is only the fruit stored in cold storages.

Therefore, keeping quality of apple assumes a very great importance. Excepting for *ambri,* which is indigenous to Kashmir region, many of the well known varieties, especially of the exotic Delicious group, have a very poor keeping quality. The supply of *ambri* is gradually dwindling even within the season proper because of general neglect of the crop and widespread infestations of mildew and scab diseases, more virulently the latter. Owing to this, the only sweet varieties which remain in the market to meet the taste of the northern and central parts of the country are those of the Delicious group. But since this group does not keep long, the northern and central parts are not left with any other suitable variety of comparative apple in the off-season. Even on scientific considerations, it is not prudent to rely only on one type because there is always the danger of widespread failure due to weather or epidemics. It is necessary to broaden the genetic base and the possibility of utilizing wild germplasm has also to be explored in this connection. Insofar as the southern parts of the country are concerned, the consumer preference is for bright coloured and sour apples. Sour apples are produced in west Uttar Pradesh hills, but their season ends early and secondly, the quantity is not sufficient to meet the entire demand. This lacuna has also to be removed. Apple scab and other diseases are already engaging due attention of scientists.

23.1.30 The elevations in the Himalayas suitable for apple cultivation can be divided into three tiers, viz., (a) less than 1,500 m. (b) 1,500 to 2,000 m. and (c) more than 2,000 m. At present, apple cultivation is concentrated between 1,500 to 2,000 m. This is because most of the varieties were introduced into India from temperate regions and suit this range on considerations of longer dormancy and low temperatures. Apple cultivation, to be successful below 1,500 m. needs varieties which have a shorter dormancy period and accustomed to milder temperatures. Such varieties are not available at present. If this defect is removed, apple cultivation will be possible at lower elevations also, where more area is available. There is experimental evidence to show that apple cultivation can be taken up with success even beyond 2,000 m. Fruit setting and colour, etc. have been found to be satisfactory but because of the colder conditions, ripening has not been to the desirable extent. If suitable varieties could be found for higher elevations, this could lead to further increase in the area under apple. However, the economics of successful cultivation at such higher elevations will also have to be examined.

23.1.31 The following two techniques are available for effecting improvement in apple :—

(i) Top working as a technique for improvement is applicable to this crop. Scientists are aware of it and it has already been applied to *ambri* in Kashmir with satisfactory results.

(ii) The latest trend in some of the horticulturally advanced countries is for giving preference to dwarf varieties. The plants grafted on dwarfing rootstocks are found to give high yields and better quality of fruits. Dwarf trees with compact canopies allow a higher density of plant population per unit area, which is an important consideration in their favour. Vertical development in this method of cultivation is prevented by training the branches to take to horizontal positions by tying by wires and strings etc. It is observed that the bearing in this way takes place within two to three years of planting as against about ten years required for the usual trees. Considerable work has been done at East Malling Research Station and the John Innes Horticultural Institute at Merton in England in this direction. Dwarfs in the name of Malling and Malling Merton series have been developed there and Himachal Pradesh has tried to import clonal rootstocks of these plants from there. The technique has given encouraging results under experimental conditions and the State is trying to advocate the same for large scale adoption on trial basis.[1] Performance of those dwarfs with dense planting and horizontal training of branches in growers fields needs to be watched with interest.

Grape

23.1.32 The availability of fresh grapes in the country follows the following pattern :—

	Place of production	Period of availability in the market
(i)	Coimbatore, Bangalore and neighbourhood	December-January
(ii)	Hyderabad-Poona-Nasik belt falling in Marathawada and Khandesh regions of the Deccan	February to mid-April
(iii)	Punjab-Haryana region and adjoining irrigated parts of Rajasthan	mid-April to June

It has to be noted that the import of grapes in fresh form from Afghanistan and Pakistan during the months of July to September helps in extending the period of availability. Since no part of the country produces sweet and well-formed berries in these rainy months,

1 Singh, H.B., 1968, Dwarf Apple Cultivation, Farmer's Bulletin No. 3, Simla, Himachal Pradesh Fruit Development Board.

the chances of import substitution of fresh grape appear to be meagre according to present indications. The main crop of grape is taken in the Peninsula. The area under this crop in the northern parts is just about a couple of hundred hectares, but there is an increasing trend towards grape cultivation even in those parts in the hope of better returns. The question of water availability during summer months in these parts is acute and grapes would have to compete with other important crops like cotton and sugarbeet. It is desirable to lay out experiments in order to determine the comparative economics of the various crops including grape which could be taken during summer. This would enable the farmers to make a choice of crops on a scientific basis.

23.1.33 One of the early hybrids that received commercial acceptance is *Selection* 7, produced at Poona by crossing *fakri* variety with *pandhari sahebi.* Subsequently, hybridization work at the IARI yielded about 20 hybrids with characters like early maturity, big bunch, high yield and sweetness. The most important grape variety of southern India is *anab-e-shahi.* Some seedless varieties selected from exotics are now available within the country e.g., Thompson Seedless, Parlete, Pusa Seedless and Beauty Seedless. There was a time when Thompson Seedless had become very popular throughout the country and opinion was in favour of utilising it for raisin production, but it did not prove to be very economical because of low sugar in plain crops. Beauty Seedless is the earliest variety for northern India, maturing between last week of May and first week of June. At present, grape research is conducted under the All-India Coordinated Improvement Project at the IARI and the IHRI Bangalore with subcentres at Tamil Nadu Agricultural University, Coimbatore; Fruit Research Station, Periakulum; Punjab Agricultural University, Ludhiana; and Maharashtra Association for Cultivation of Sciences at Poona. These centres are already engaged in the work of collection of germ plasm, breeding of new varieties, use of growth regulators and other agro-techniques including pruning, training, rootstocks and nutritional requirements. The suggestion made in the preceding paragraph also requires attention of the concerned institutions.

Pineapple

23.1.34 Pineapple is mainly grown in tropical countries and lends itself very well to processing. Due to this, it has become one of the most important commercial fruits of the world. It was introduced into India from Brazil in 1548, but its cultivation on a field scale started only about three or four decades ago specially on the West

Coast and in Assam, Meghalaya, Tripura and Manipur in the North-Eastern Region. The areas reclaimed from 'shifting cultivation' in the North-Eastern Region offer good scope for expansion of this crop. However, pineapple has not so far attained a position of importance among the major fruits cultivated in the country. A few canning units have been established in the growing areas. At present the average yield of pineapple in India is very low and is estimated to be 10—12 tonnes per ha as against 60—70 tonnes in Hawaii. While research on almost all aspects of pineapple cultivation is now under way at the IHRI at Hessarghatta and Banana and Pineapple Research substation, Trichur, similar research work needs to be carried out in other pineapple growing areas particularly in the States of Assam, Maharashtra, West Bengal and Orissa. Attention needs to be paid in the first instance to the optimum time of planting, standardisation of population density for each region, fertilizer requirements, time and dose of fertilisers, foliar nutrition, irrigation requirements, mulching treatments, time and dose of growth regulator treatment, control of mealybug pest and black rot and other diseases found in some areas. Work also needs to be taken up on activating slip production using vegetative bud dormancy breakers and possibility of avoiding or reducing the population of unproductive off-types. There is need to improve the quality of variety *Kew* now grown for canning purposes and the variety *Queen* grown for table purposes. At present, a number of defects have been reported in variety *Kew* with the result that canned pineapple slices cannot compete with similar products available in the world market. A long range breeding programme needs to be taken up in this crop in order to get some better varieties than the available *Kew* for canning purposes and *Queen* for table purposes.

Walnut

23.1.35 Walnut grows in the Kashmir valley and the mountainous regions of Himachal Pradesh and Uttar Pradesh. Walnut trees are normally planted sporadically in ravines, on bunds and in backyards of houses. Majority of the walnut trees at present grown in the country are of seedling origin. These bear fruits of mixed types. Non-availability of grafted plants of good varieties has been the main bottleneck in extending the area under quality walnut trees. Steps will have to be taken to make available the grafts in required numbers. The grafts start yielding from fourth year onwards as against 8 or 10 years or even more in the case of seedling trees. The walnut growing States are raising plantations in forest areas as a part of their regular plantation programme. The present estimated area of around 6,000 ha

could be easily doubled by 2000 AD. If appropriate production techniques are adopted and proper care of plantations taken and the area under this crop reaches the mark of 12,000 ha or more, production can certainly be expected to be 2 1/2—3 times the present level. This would give sufficient scope for export promotion.

Fruits of Dry Areas

23.1.36 There are numerous xerophytic or semi-xerophytic shrubs or trees growing wild or cultivated, the fruits of which are consumed in dry areas. The most common among these are many kinds of *bers* (*Zizyphus spp.*), *bel* (*Aegle marmalos*) and dates. Attempts have been made every now and then to examine the possibilities of date cultivation in India. Some recent experiments were conducted in Abohar (Ferozepore District—Punjab). The present indications are not favourable even for its cultivation in Rajasthan. However, the agricultural universities of the concerned States, specially Rajasthan, could certainly continue their endeavours to become self-sufficient in this fruit. There are, of course, many fruits like papaya, pomegranate and fig, which give a good performance with a little irrigation support even in dry conditions which are quite common in Rajasthan and the Deccan plateau. The common problems of all fruits—whether of dry or humid areas—are considered in the succeeding paragraphs. There is a good possibility for growing more of citrus, guava and grapes in the Rajasthan Canal tract.

Future Lines of Research Common to all Fruit Crops

23.1.37 There are certain research problems which can be viewed in common for all the fruit crops. These are mentioned below :

(i) The problem of considerable variation in respect of yield and quality even in the same cultivar has been referred to earlier in respect of the important fruits. This problem is commonly met with in many other fruit crops also, e.g., *sapota, ber, aonla* and jackfruit. Therefore, it is essential that clonal selection is made to choose the best cultivars in all fruit crops, wherever feasible.

(ii) A sample survey conducted by the Institute of Agricultural Research Statistics indicates that not even 1/2 kg of fertilizer is applied to a fruit plant in many areas. There is an utter neglect of tillage and the application of irrigation. The agronomic aspects require more attention in general. Recent researches indicate that the nutritional status of leaves is a better index of mineral requirements of plants

than the nutritional status of soil. Thus, to ensure that adequate fertiliser doses are applied to horticultural plants, it is necessary to establish foliar analysis laboratories and organise advisory service. This could be done by the agricultural universities.

(iii) The area contemplated under fruit crops is 4 Mha for 2000 AD, but it is not possible to provide irrigation to more than 1.25 Mha of this area owing to needs of other crops. Therefore, researches are necessary to define clearly which of the crops can be made to depend solely upon rainfall and in which parts, which crops will need full dependence upon irrigation water and which crops could be grown with partial dependence on rainfall as well as irrigation and in this case it is necessary to define the periods when reliance could be made on rainfall and when on irrigation. This is necessary to plan a judicious use of irrigation water.

(iv) In the days to come, the use of plant protection chemicals is also likely to increase. The problem of residual toxicity will have to be successfully tackled in order to avoid health hazards and this task will also require considerable experimentation.

(v) The possibilities of improving production through top-working exist not only in the case of mango but also in jujube (*ber*), grapes, guava and custard apple. Studies are required to be carried out to standardise techniques of top working for different crops for large scale adoption.

(vi) It is necessary to establish model orchards in each district by expert horticulturists to determine the economics of their production. These orchards will also prove to be centres of practical demonstration in better methods of cultivation.

(vii) In all the above mentioned suggestions, agricultural universities should play a leading role. On the developmental side, establishment of progeny orchards and supply of genetically uniform nursery stock is of urgent necessity.

After all these measures are taken, it is considered that the production of all kinds of fruit crops can easily be doubled.

23.1.38 Insofar as the Central set up for horticultural research is concerned, there is a Division at the IARI and an Indian Horticultural Research Institute which was established in 1968 at Hessarghatta. A Central Mango Research Station has been started recently at Rahmankhera (Lucknow). An all-India Coordinated Fruits Improvement Project has been working at these institutes with a coordinating

cell for about five years. Mango, banana, citrus, papaya and guava are indeed such fruits where, although regional researches can be conducted at the agricultural universities, an all-India approach and coordination at the Central level is also meaningful. As against this, there are crops of temperate regions like apple, peach, pear, plum, apricot, cherry, blackberry, gooseberry and loganberry for which the concerned problems have to be attended to exclusively in the regions concerned. Many of these are considered to hold promise for export. The two regions, viz., (a) the contiguous belt comprising Kashmir valley, Himachal Pradesh and western hills of Uttar Pradesh and (b) Himalayan West Bengal and the hills of North-Eastern Region are most suited for these crops. Hence small institutes of Temperate Fruit crops could be established in both these regions in order to do full justice to the crops.

23.1.39 There are crops like *litchi, ber, chiku* (*Achras-sapota*), grape, pineapple and walnut, which are localised in distribution. In such cases, research and developmental activity of a purely localised character is sufficient and, therefore, such crops could be left to be tackled by the States concerned. In addition, there are many country fruits like *jamun* (*Eugenia*), *karonda* (*Carissa*), *mahua* (*Madhuca*), *aonla* (*Phyllanthus*), *kaitha* (*Feronia*), *bel,* which are consumed to a considerable extent but which do not normally enter the official estimates. Many of these either grow wild or are found scattered in many of the groves. Their condition requires to be improved and this is also a sphere for regional responsibility.

2 TUBER CROPS

23.2.1 Tubers represent a group of crops which accumulate carbohydrates in the enlarged underground modified stems or roots. The commonly known tubers are : potato, sweet potato, tapioca (cassava), yam (*Dioscorea*), various aroids like *Colocasia, Alocasia, Xanthosoma* and *Amorphophallus* (elephant foot yam or *suran*) and arrowroots (*Maranta, Curcuma* and *Canna*). Of these, potato prefers cool climate, rich soil and better care. Other crops can be grown even on marginal lands of low fertility and investment on planting material is also less. Most of these crops are grown by small farmers, sometimes with inter-crops. Potato, sweet potato and tapioca are important from all-India point of view whereas others have either much less area under them or are confined to certain regions only. Potato is used in vegetable preparations throughout the country all the year round. Tapioca widely serves as a supplement to rice or even exclusively replaces it

in Kerala. Such use of tapioca is also common in parts of Karnataka, Tamil Nadu and Andhra Pradesh. Sago made from tapioca is popular throughout the country. Being rich in carbohydrates, the three important tuber crops can to varying extent supplement cereals in India. In various European countries the per capita consumption of potatoes is higher than that of cereals (e.g. Germany 64, Belgium 59, Denmark 58 and Sweden 58 per cent of total cereals and potatoes). The base already exists in the country for the popularisation of these commodities, because these are already used by people to some extent or the other. It is a question of orienting public taste a bit more and increasing production to meet the needs in this new perspective. This is very necessary if deficit cereal production in years of adverse weather conditions has to be met from the internal resources rather than by imports.

23.2.2 Export prospects afford another reason for increasing production of tuber crops like potato and tapioca. There was a time when India depended mainly on foreign countries for its requirements of seed potato. This had its ill effects inasmuch as the most pernicious maladies like wart and nematodes got firmly rooted in the country. In order to contain and combat this situation, the Commission recommended a ban on imports of foreign material in its Interim Report on Potato Seed (August, 1972). The country is in a comfortable position to do so because of the rapid strides made in developing appropriate varieties to suit all kinds of situations and requirements. The country can look forward to put its produce in foreign markets. The volume of exports has been small and fluctuating uptil now. Nepal is the major buyer of potatoes from India, Trucial Oman, Bahrain Island, Muscat, Kuwait, Saudi Arabia and Mauritius used to import considerable quantities of potatoes from India at one time, but have stopped doing so now. The Study Group (Export Sector) on Agricultural Commodities and Agriculture-based Industries of the Ministry of Agriculture & Irrigation in its report in February, 1965, stressed the need for promoting export of potatoes to Afro-Asian countries to the extent of 2 per cent of production and suggested a target of 50,000 tonnes by the end of the Fourth Five Year Plan. The main recommendations of the Group were as follows :—

(i) The Ministry of International Trade should announce and publicise the export quantity in advance so that prospective exporters could act in time.

(ii) Rigid compulsory quality control should be enforced for the export of potatoes.

(iii) The Indian Merchant Fleet should acquire a few refrigerated ships for export of perishable commodities including potatoes.

(iv) Transport facilities should be developed in potato growing areas to reduce spoilage.

(v) A Potato Development Board should be set up in the Ministry of Agriculture and Irrigation to develop production, marketing and export of potatoes.

23.2.3 Possibilities of exports to Pakistan cannot be very bright, because opportunities for potato production in that country are more or less the same as in India. Bangladesh can take seed potatoes from the plains as well as Meghalaya hills. It appears that the Dutch variety 'Bintje' finds favour in Bangladesh. There should be no difficulty in developing disease-free stocks in India of 'Bintje' or of any other variety acceptable to Bangladesh for supply at competitive rates. The potatoes grown in south Indian hills could meet the need of Sri Lanka. There are also other countries in the South East Asia, Middle East and Africa which are not ideally suited for potato production, specially seed. India could supply seed as well as table potatoes to such countries. At present, the countries in the Middle East are probably getting most of their supplies from Europe and the countries in the South East Asia from Japan. These exporting countries can grow only one crop of potato in summer in a year. However, India is more favourably placed and can grow potatoes in different seasons of a year in one part of the country or the other. India is, therefore, in a better position to supply potatoes in accordance with the needs of importing countries.

23.2.4 Processing and industrial utilisation can give impetus to the production of some of the tuber crops. The possibilities for such utilization are indicated below :

(i) Potato affords less chance for utilisation in the manufacture of starch because of competition from cheaper raw materials like maize and tapioca. However, processing of potato for human consumption into dehydrated, sundried and canned products is an imperative necessity for saving the producers from occasional slumps in prices due to temporary gluts often caused during harvest period. Even now, potato chips are produced in India by a large number of small-scale units, mainly for consumption by a relatively small proportion of the urban population. Dehydrated potatoes in the form of cubes or slices are produced for the defence forces and the estimated annual production is only about 1,000 tonnes. Similarly, potatoes are canned mainly for the defence forces, but in smaller quantities. However, if experience in other countries is any guide, the demand for various processed products is likely to increase due to increased urbanisation and preference

for ready recipes necessitated by the increase in the number of working women.

(ii) Tapioca is being utilised for a variety of industrial purposes and also in foodstuffs. Large quantities of this tuber are expected to be required for the manufacture of indigenous food under the children's feeding programme, the formula for the preparation of which has been developed by the Cooperative for American Relief Everywhere (CARE) organisation in collaboration with the National Research Institute of Nutrition, Hyderabad, and the Central Food and Technological Research Institute, Mysore. Under this scheme, the basic material, viz., cassava products, are being supplemented with materials like groundnut, Bulgar wheat etc., to make the net product a balanced one. Such a programme, which is now confined to Kerala, is likely to get extended to other States also.

(iii) Sweet potato is widely used in India as food after boiling and frying. In the USA considerable quantities are canned after peeling. Sweet potato flour is also used in the preparation of *phirni*, puddings, cakes, biscuits, etc. Japan utilises sweet potato for starch production which is widely used in various industries. Dried and dehydrated sweet potato is also considered useful source of carbohydrates. Vines of sweet potato are considered to be good for feeding animals.

(iv) There are possibilities of utilising yams for commercial and industrial purposes. Starch is extracted on a commercial scale from tubers of *Dioscorea alata*. Many wild species have been found to be the sources of sapogenin having a steroid nucleus. These steroids are finding increasing use in the synthetic drugs such as cortisone, birth control pills and in sex hormones.

(v) Arrowroot starch is valued as food especially for infants, invalids and convalescents. It is also used in the production of biscuits, cakes, puddings, jellies and as suspending agent in the preparation of barium meals.

23.2.5 Prior to the Second World War, the entire quantity of starch required in the country was imported. During the war, import was completely stopped and the textile industry had to fall back upon indigenous resources and cassava starch produced in the country promptly took the place of imported stuff. This position continues. In addition, there is vast scope of export of finished products to other countries such as the UK, Belgium, West Germany and East European countries etc. Even as early as 1959-60, sago was exported to Sri

Lanka, Pakistan and USSR. Some brands of cassava material of Kerala origin were introduced in German markets a few years back and these elicited favourable response but according to some reports higher shipping rate of cassava affected exports. India did export cassava flour and cassava starch worth £50,000 till 1964 to German Democratic Republic, the Netherlands, Hungary and other European countries. As such, the base for export for the processed and industrial products does exist for tuber crops. There is need to promote production of the needed products. Of course the quality standards and cost factor will always matter to capture markets. The cost will automatically come down reasonably when production increases. Thus, the above survey should be quite assuring that there exist ample opportunities to aim at greater and greater production of tuber crops in the country. These crops are dealt with individually in the succeeding paragraphs.

Potato

23.2.6 The area, production and yield statistics of potato are given in Appendix 23.2—Statement I. The main features of area and production are described below :

(i) At present, about 0.5 Mha are under this crop and the average all-India yield is about 9 tonnes/ha.

(ii) The crop is grown almost in all parts of the country. Uttar Pradesh, Bihar and West Bengal account for 34, 20 and 14 per cent respectively of all-India area under potato. The area varies between 2 and 5 per cent of the all-India in the case of Assam, Orissa, Himachal Pradesh, Madhya Pradesh, Meghalaya, Punjab, Maharashtra, Tamil Nadu and Karnataka States. Each of the remaining States account for less than one per cent of the country's area under potato.

(iii) The yields are between 4 and 5 tonnes/ha in Assam, Himachal Pradesh, Meghalaya, Maharashtra, Karnataka and Jammu & Kashmir. The importance of Himachal Pradesh lies not in yield standards but in its suitability for seed production. The crop is generally taken on hill slopes with poor fertility status of soils and under the constraint of moisture and hence perhaps the yields are low. In some parts of other States, the crop is grown under rainfed conditions.

(iv) In the major producing areas i.e., Uttar Pradesh, Bihar and West Bengal, the yield is between 9 and 12 tonnes/ha

(v) In minor areas, Haryana records about 16 tonnes/ha and

Gujarat 25 tonnes/ha. Gujarat's record is in conformity with the better efficiency of crop production in general. Moreover, this crop is usually taken there in river beds with intensive care.

In regard to estimates of yields, it may be mentioned that though the objective method of crop cutting surveys has been introduced in some parts of the country viz., Assam, Bihar, Madhya Pradesh, Orissa and West Bengal, in other States the estimates of yield are based on the traditional or annawari method and are, therefore, subjective in character. It is felt that the yield estimates based on the annawari method fail to reflect the effect of improvements which have taken place in recent years. This is specially pertinent in the case of Uttar Pradesh, where the Government has really made persistent efforts for the development of the crop. The State Government has set up two potato research stations at Mukteswar and Farrukhabad. These are supported by about a dozen multiplication farms. The Agricultural University at Pantnagar has also been devoting considerable attention to potato research. The State has made significant progress in the distribution of healthy seed and related inputs. With such a background, it is hard to believe that the yields in the State should stagnate around 9 tonnes/ha. The yield standards achieved by the State research farms as well as the Central Potato Research Institute (CPRI), Simla, are around 30—35 tonnes/ha. In view of this, there is an urgent necessity to extend the method of crop cutting survey for estimation of yield of potato to other important producing States including Uttar Pradesh so that a correct appraisal of the existing position becomes possible. Unless this is done, future plans will be ambiguous as far as yield targets are concerned.

23.2.7 The question as to why the area and production of potato have not increased is examined below :

(i) Potato is both capital-intensive and labour-intensive crop. The crop is quite exacting in its requirements of inputs such as seed, fertilizers, fungicides and pesticides and assured irrigation. Of these, 'seed' is particularly important as it accounts for nearly 50 per cent of the overall production cost.

(ii) In the plains, the crop has to be stored over hot summer months and losses of seed and table potatoes in storage are particularly high. Although the problem is partly solved with the development of the cold storage industry, only about one-third of the crop is still being stored in the cold stores. The inadequacy of cold storage capacity is often exploited by owners of private cold stores and traders. Malpractices may be of two kinds, viz., (a) charging

exorbitant rates for storage and (b) fictitious booking of space which could create impression of artificial over-production or glut, forcing the growers to part with their produce at an unremunerative rate. However, there is a genuine difficulty faced by the cold storages and that is about the frequent power breakdowns. This is also sometimes played to the disadvantage of the grower inasmuch as he is made to lose his share under the plea of spoilage.

(iii) Even in the hills, where the crop is stored over winter months more or less under similar conditions as in the Western countries, the storage losses are considerable as tubers are liable to infection with late blight and other rot-causing organisms.

(iv) Temporary gluts after harvest often result in price crashes which introduce a risk factor and act as a disincentive.

(v) The low yield per unit area can be ascribed to (a) ecological restraints in certain areas, (b) non-availability of disease-free seed of the most suitable varieties adapted to different agro-climatic regions, (c) high incidence of pests and diseases to which the crop is subject, and (d) use of sub-optimal inputs resulting from (i).

23.2.8 The result of these factors is that an ordinary cultivator does not venture to take up this crop. The crop has, therefore, not spread into the interior and is mostly confined to the peripheries of towns and cities. It is either grown by *kachhis* (small vegetable growers) or some prosperous farmers, who have developed particular specialisation in this crop. At present, the cultivation of the crop is mostly restricted to compact blocks in certain districts near big cities, e.g., Patna city and Bihar Sharif in Patna district, Farrukhabad, Burdwan, Hooghly, Meerut, Jullundur, Shillong, Simla, Ootacamund and Poona. As a result of the way the cultivation has developed, the crop is grown repeatedly in the same plot of land and long rotations are not followed. In fact, even two crops are sometimes grown in the same area in the same field successively. As a result, it has not been possible to get rid of many pests and diseases. In temperate countries, potato figures as part of a regular six or seven crop rotation and yet as much as 15 per cent or more of the cropped area is put under the crop. It should be possible to follow longer crop rotations for potato as a part of arable cropping even in India. When cold storage and marketing facilities become widespread, there should be no difficulty in extending the area under the crop even in the interior villages. It has been envisaged in Chapter 56 on Marketing, Transport and Storage that it should be possible to provide an all purpose primary marketing centre within every five km radius. The problem of cold storages and

other aspects of marketing have also been duly dealt with therein. Certain recommendations pertaining to cold storages have also been made in our Interim Report on Potato Seed (August, 1972).

23.2.9 This crop represents a well organised set up of research and developmental activities. The main points of progress are summarised below :

(i) Evolution of new high yielding varieties such as (a) *Kufri Chandermukhi* for taking early crop in northern States and main crop in areas of short and mild winters, (b) *Kufri Sindhuri* and *Kufri Chamatkar* for taking main crop in the areas of long frost-free winters, (c) *Kufri Sheetman* for areas subject to frost, (d) *Kufri Dewa* for areas where potatoes have to be kept in ordinary stores for prolonged period, and (e) *Kufri Jyoti* and *Kufri Muthu* for the northern and southern hills, respectively, where late blight causes heavy damage.

(ii) Development of agronomic technology in relation to (a) breaking dormancy for effective use of freshly-harvested dormant seed for immediate use, (b) chemical control of weeds, (c) cultural practices, (d) use of potato in multiple cropping systems, (e) fertilizer use, and (f) water management.

(iii) Storage and utilization studies with regard to (a) factors affecting the storage behaviour of the produce, (b) use of chemicals for prolonging dormancy, (c) sun-drying of potatoes, (d) design of cool country store for short-period storage of potatoes, and (e) changes in the composition of tubers under different conditions of storage.

(iv) Engineering aspects leading to the design of (a) seed-treatment chamber for breaking dormancy, (b) a crust breaker, and (c) a tuber-cutting machine.

(v) Pathological and entomological studies on (a) distribution of diseases and pests in the field and stores in the different potato-growing areas, identification of casual organisms and their races and the development of methods of controlling them, (b) inactivation of leaf-roll virus at high temperature storage, (c) virus-vector relationship, (d) tuber treatments for preventing seed-piece decay and for disinfection against surface-borne diseases, (e) surveys on the appearance and build-up of aphids transmitting viruses particularly in the plains leading to the development of 'Seed Plot Technique' for producing healthy seed potatoes in the plains of India, and (g) use of systemic insecticides in

keeping down the incidence of aphid-transmitted viruses.

(vi) Some of the States have set up potato development units in the Departments of Agriculture/Horticulture. Good working relations amongst the potato development agencies in the States, the CPRI and the Production Division in the Union Ministry of Agriculture and Irrigation have been established and some progress has been made particularly with reference to seed production. A special Potato Development and Seed Multiplication Committee was set up in 1966-67 with the Agricultural Commissioner to the Government of India as the Chairman and the representatives of the CPRI and those of the State Governments/National Seeds Corporation (NSC) as members. This Committee meets twice a year and arranges for the distribution of breeder and foundation seed and chalks out the seed multiplication programmes. The participants in the multiplication programmes are the NSC, Central State Farms and the States of Punjab, Uttar Pradesh, Bihar, Rajasthan, Haryana and Himachal Pradesh.

23.2.10 The Government is aware of the importance of this crop. In view of the food shortage in the country, the Union Ministry of Agriculture and Irrigation in consultation with the ICAR decided to increase both the cultivation and consumption of potatoes and other tuber crops during 1974-75; the measures contemplated being as follows :

(i) Potato cultivation is generally concentrated in blocks near towns and industrial centres. Cultivation should be extended around such blocks or pockets of existing potato cultivation.

(ii) There is scope for inter-cropping potatoes in sugarcane planted in autumn in Maharashtra, Gujarat and eastern parts of India.

(iii) Since late blight resistant varieties are available, potato cultivation in spring in Punjab and parts of Haryana could be revived with the use of late blight resistant varieties, e.g., *Kufri Jyoti* or by planting freshly harvested tubers from autumn crop after treating them for breaking dormancy.

(iv) Cultivation of potatoes should be popularised in kitchen gardens in towns.

(v) There may be possibility of increasing potato cultivation in the areas liable to floods in Bihar, West Bengal, Uttar Pradesh and Assam.

(vi) Considerable areas in West Bengal and Bihar could be utilized for planting potatoes with the seed of late blight resistant varieties from Himachal Pradesh. Such seed should, however, be treated with thiourea or gibberellic acid for breaking dormancy.

(vii) Varieties such as *Kufri Sindhuri* are considered to be poor man's crop which can be grown with lower seed rate and which have lower rate of degeneration and low phosphate requirements.

(viii) In view of the shortage of fertilizers and the high costs, the optimum dosages may be reduced as follows :

(a) For main crop, fertilizers may be applied at 100 kg N/ha, 60 kg P_2O_5/ha and potash 60 kg/ha. If the farmyard manure at 40 tonnes/ha is applied, the application of phosphate and potash can be omitted. With lower dose of farmyard manure, the dose of phosphate and potassium could suitably be adjusted.

(b) For early crop, the fertilizer doses may be 80 kg N/ha, 80 kg P_2O_5/ha and 40 kg K_2O/ha, on very sandy soils, the dose of nitrogen should be increased by 20 per cent.

(ix) Power supply should be ensured or so adjusted that the crop does not suffer particularly during the tuberisation phase and water supply is assured.

(x) Early lifting of crop should be discouraged and emphasis should be on the main crop for maximising the yields.

(xi) Paddy husk may be used as mulching to reduce demand for water and to control the weeds.

(xii) Pockets of deficit production should be located so that supplies of potatoes should be directed to needs of such deficit pockets.

(xiii) Potatoes may be popularised as children's food.

(xiv) One meal in a week may be popularised as non-cereal meal so as to increase the consumption of potatoes.

(xv) The sale of potatoes should come under regulated markets.

(xvi) Sundrying may be popularised as cottage industry.

(xvii) Pre-sprouting of seed potatoes should be done to give the plants early start.

(xviii) A booklet may be prepared by the CPRI containing packages of practices of potato cultivation in each region.

(xix) Training courses may be organised in which CPRI and the agricultural universities may impart the necessary training

to extension workers. Roving teams should visit the potato growing areas to advise the farmers in the methods of potato cultivation and seed production to enable them to quickly improve the seed stocks by timely roguing and early removal of haulms etc.

23.2.11 The contemplated measures outlined above indicate that the Government's awareness is so complete and the research setup so informed of the problems and so adequately developed that there is hardly any need for us to make additional recommendations in this regard. In fact, the implementation of the programme brought out one important lacuna which, if not considered alongside the production programme, is likely to act as a disincentive to increase production. The production programme resulted in a glut resulting in distress sales. This brings out the need for keeping in readiness an advance programme of effective distribution, whereby the produce from the growing areas could be quickly dispersed to consuming centres situated in various parts of the country. It is also necessary that any remaining surplus even after such a planned distribution is stocked appropriately in cold storages. On technical side, development of disease and pest forecasting techniques with special reference to late blight and aphids, integrated disease and pest control and problem of residual toxicity of pesticides, use of polyhaploidy and tissue and organo-culture techniques in developing new improved varieties have to engage attention. It has often been proposed that Potato Development Boards should be set up at the Centre and in the States. We are not in favour of increasing the number of Boards. In the case of this crop particularly, we feel that the normal governmental setup should suffice. In our Interim Report on Potato Seed we have suggested the creation of Potato Seed Development Councils, both at the Centre and in the States. If necessary, the scope of these Councils could be enlarged to meet the needs of general development. Considering the present status of the crop, it should be possible to treble the area and double the yield by 2000 AD (i.e., 1.5 Mha and 20 tonnes/ha respectively). The crop will require total irrigation support except in areas where it is cultivated in river beds or in the rainy season.

Sweet Potato

23.2.12 The all-India average (1968-69 to 1970-71) area and yield of sweet potato are 227,000 ha and 8 tonnes/ha respectively (Appendix 23.2—Statement II). Though this crop is grown all over the country, it is mainly concentrated in Bihar, Uttar Pradesh and Orissa which account respectively for 34, 25 and 12 per cent of area. Karnataka

and Madhya Pradesh each account for another 5 per cent of all-India area. The area ranges between 2 and 4 per cent in the States of Assam, Maharashtra, Kerala, Tamil Nadu and Andhra Pradesh; the contribution of remaining States being 1 per cent or less. Uttar Pradesh records an average yield of 10 tonnes/ha. The yields generally vary between 5 and 8 tonnes/ha. It is one of the most neglected crops. A few varieties were released as a result of research work at Pusa. These, however, did not spread very much. Some introductory trials were conducted also in Vivekananda Laboratory, Almora but their impact was also not noteworthy. As a result, varieties of unknown purity and performance are prevalent in the country. Most of these are disease-ridden. The material, which is used as seed, is what passes from farmer to farmer or village to village. The responsibility for sweet potato research at present devolves on the Central Tuber Crops Research Institute at Trivandrum (CTCRI). Attempts are being made at this institute to develop varieties through selection and hybridisation to achieve high yields with high starch and sugar content. Two hybrids, H41 and H42, have been found to be high yielders (25—35 tonnes/ha). The Institute is also making endeavours towards standardising agronomic techniques for growing sweet potato in and around Trivandrum.

23.2.13 Like potato in the case of sweet potato, two to three crops can be taken in a year depending upon the agro-climatic conditions. This crop is planted as early as in March in north India, wherever irrigation facility is available. Otherwise, the main crop is generally taken rainfed during kharif season commencing from June or July. In West Bengal and Bihar, it can be planted in September also. In Maharashtra and Gujarat, it is planted either in July or in November. In south India, it can be planted in September as also in March. This shows a wide spectrum of planting periods followed in the country. Once again, the importance of local variations is brought out very clearly. Sweet potato, being a short duration crop, can be fitted into various crop rotations varying from place to place. Accordingly, meaningful research to improve the general standard of this crop and its yield can best be conducted on a decentralised basis. However, as in the case of sugarcane, seed setting in sweet potato can best take place under tropical conditions of south India and in this respect the facilities, which Trivandrum offers, cannot be matched in northern parts. Therefore, basic research work including that on breeding can continue at the CTCRI. As in the case of sugarcane, where the fluff after having been developed at Coimbatore is distributed to other parts for further selection and multiplication work, so also in the case of sweet potato, the selection and multiplication work subsequent to the basic work at Trivandrum has to be done in different States. The various States

should develop the agronomic and plant protection techniques in accordance with their respective needs. As the area under sweet potato is small, there is no need to start separate stations; the facilities existing at the agricultural universities and at the farms of the State Departments of Agriculture/Horticulture can be utilized for this purpose. There is a good scope for raising the average yield levels up to about 20 tonnes/ha. The area under this crop can also be raised to half-a-million hectares.

Tapioca

23.2.14 The all-India averages (1969-70 to 1971-72) of area and yield of tapioca are 350,000 ha and 15.5 tonnes/ha. Kerala has a monopoly of cultivation with 85 per cent of area and 90 per cent of production. Tamil Nadu comes next with 12 per cent of area and 9 per cent of production. The area under tapioca in the country can be raised to 1.0 Mha. In the major producing State viz., Kerala, there already appears to be saturation in the matter of tapioca area. The neighbouring State of Tamil Nadu, however, affords an opportunity for area extension. Efforts have also been made in this State for industrial utilisation of tapioca and there are already 700 small scale sago manufacturing units in the State. At present these units draw their supplies of tapioca mainly from Kerala. It is necessary to increase the area under tapioca in Tamil Nadu to feed these units. Availability of land is not likely to be a constraint in this State. Karnataka has also got suitable soil and climatic conditions for growing tapioca on the western side. Andhra Pradesh and Assam Region provide suitable conditions for growing tapioca and can undertake substantial increase in area. Maharashtra and Orissa also offer some scope. Keeping these possibilities in view, the area under this crop in 2000 AD might be envisaged as follows:

State	Area in thousand ha
Kerala	325
Tamil Nadu	200
Karnataka	125
Maharashtra	50
Andhra Pradesh	125
Orissa	75
Assam Region	100
	1,000

23.2.15 Tapioca was introduced in Kerala by Portuguese sailors in the 17th century. They gifted the cuttings which they had brought with

them, to the then Maharaja of Travancore. Naturally, the first plantings were made in and around Trivandrum, which was the capital of the State. It was used only as food in the beginning. Its cultivation spread from grower to grower. It was mostly grown on holdings of small farmers. It did not receive much attention in the early years of its introduction. Occasional food shortages in the State, however, led to its popularisation. Certain varieties were imported from Malaya and other countries. The plant gradually attracted the attention of the scientists in Kerala University. Some investigations were undertaken, but these related mainly to problems of fundamental nature, e.g., cytology, embryology, etc. Research work was also subsequently undertaken by the Department of Agriculture of the State. This was, however, confined mostly to aspects like method of planting and application of manures. The question of varietal development in tapioca did not receive attention up to this stage. The local varieties, which persisted, were only the derivatives from original stock.

23.2.16 Kerala is a State which has been having its agriculture oriented mainly towards growing crops which have great export potential, e.g., rubber, coffee, cardamom, pepper and ginger. Agricultural efforts were, therefore, mostly limited to the improvement of such crops and when tapioca did receive attention, it was also from the point of view of developing varieties which were suitable for starch and sago. Starch and sago could provide market outside as well as inside the country. The ICAR financed a scheme in Kerala University for improvement of this crop. The aim in evolving new improved varieties was high yield with high starch content and thin rind characters, which are prized for industrial utilisation. The limited germ plasm which was maintained at the Kerala University provided nucleus material to the CTCRI. This collection was further enriched by exotic varieties from a large number of tapioca growing countries like Brazil, Venezuela, Argentina, Colombia, Uganda, Senegal, Tanzania, Madagascar, Ghana, Fiji, Sri Lanka, Malaya and Thailand. From the hybridization programme carried out since 1964, involving both indigenous and exotic stocks, about a dozen hybrids recording higher yield than the local varieties have been isolated. The maximum yield obtained so far in experiments is 80 tonnes/ha. With the increase in tapioca area in Tamil Nadu, the State Government has also established a research station at Salem, mainly for adaptive trials on this crop.

23.2.17 There are broadly two varieties of tapioca viz., sweet and bitter, the bitterness depending upon the quantity of cyanogenic glucoside. Sweet varieties are mostly used for domestic consumption as food. Bitter varieties, on the other hand, are utilized for industrial purposes in the manufacture of starch and sago. Most of the

hybrids available at present are very poor industrial strains but their cooking quality is inferior to that of the widely cultivated and popular varieties used as food. There are very few improved varieties, like M4, which are also popular for eating. This lacuna needs to be filled up and a clear-cut plan of evolving varieties with emphasis on each of the aspects requires to be chalked out. The varietal development programme should take into consideration the needs of different agroclimatic regions. Certain characters which can be kept in view are stated below:

(i) Tuber size : For domestic consumption, the size of tuber is of great significance. Medium tuber size facilitates purchase of small quantities by the poorer sections, who cannot afford to buy large tubers weighing 1 to 2 kg each.

(ii) Stalked tubers : It is known that stalked tubers have better keeping quality than the stalkless. When separated from the plant, stalkless tubers immediately start getting spoiled at the cut end. Where a stalk is present, spoilage is delayed. Development of varieties with stalked tubers would thus be of advantage.

(iii) High drying ratio : Raw tubers of tapioca cannot be stored as such for long. They start getting spoiled within a day or two after harvest. The practice of burying harvested tubers in moist sand which is known to retain tuber quality for about a week is resorted to in certain places. For long distance transport, tubers are coated with a thin layer of wet soil, but this again is effective in retaining freshness of tubers for a few days only. When tubers are to be kept for more than the usual period, these are cut into pieces and sun-dried directly or after parboiling made into chips. In such cases, varieties with better recovery of dried product assume greater importance. It will also be better if attempts are made for breeding varieties which can keep their quality for long.

(iv) Plant size : Assam, Orissa, Andhra Pradesh, Karnataka and Tamil Nadu have many plantation crops. Some farmers may like to grow tapioca in these plantations, which means growth under conditions of congestion and partial shade. In order to meet such situations, there have to be some varieties with small plant size, less vegetative spread and capable of thriving under shade.

(v) Early maturity : Varieties which are early maturing and of short duration and more suitable for adoption under

crop rotation programme and multiple cropping patterns. Such varieties will encourage the introduction of the crop in new areas.

(vi) Mosaic resistance : Tapioca mosaic reduces the yield of tubers upto 35 per cent. Varieties resistant to this virus will help increase production.

23.2.18 The primary responsibility for research work has to continue to rest with the CTCRI. However, as ultimately the crop will have to be grown in various parts of the Peninsula as well as other States like Assam, it is necessary that the varieties and techniques which are developed at the CTCRI are tried for local adaptability in the States concerned. This will mean an equally important involvement of the States. The involvement may be on the same pattern as suggested for potato and sweet potato. The CTCRI can solicit cooperation of the agricultural universities of the States even in its own programme of primary research. It may be mentioned at this stage that breeding of mosaic resistant varieties is a long range programme. Therefore, an interim plan of action for immediate adoption for the purpose of growing disease-free material is equally necessary. All the existing varieties can be screened for resistance for this purpose. Moreover, prophylactic schedules of control can be popularised to destroy white fly, *Bemesi sp.*, which acts as a vector for mosaic disease. This interim programme also needs the cooperation of the CTCRI, agricultural universities and the Departments of Agriculture/Horticulture of the States concerned. With improvements, it should be possible to raise the general yield level at least to 40 tonnes/ha by 2000 AD.

Combined production from potato, sweet potato and tapioca

23.2.19 Possible production from these three crops by the end of the century might be put at 80 million tonnes (potato 30, sweet potato 10 and tapioca 40 million tonnes). The entire production will not be available for human consumption, because provision has also to be made for (a) seed, (b) wastage, (c) industrial uses and (d) export. Estimates in regard to these are discussed below:

(i) Seed : The existing requirement of potato for seed is of the order of 10 to 15 per cent of production. Requirements of sweet potato and tapioca for this purpose are negligible, as these crops are propagated through stem-cuttings. The percentage of potato used for seed is high due to low per hectare yield. When the yield level improves, this percentage will come down. Taking the requirement of potato for seed as 10 per cent, the

quantity needed will come to 3.0 million tonnes.

(ii) Wastage : The losses which occur from harvest to disposal are high because of the perishable nature of these commodities. Although no accurate estimates of losses are available, these can be assumed to be at 25—30 per cent of production at present. Losses are expected to come down when improved methods of handling, transport and storage are employed in future. It can be assumed that these losses will be reduced to 10 per cent by 2000 AD, i.e. 8 million tonnes.

(iii) Industrial Uses : At present only tapioca has industrial usage. Chiefly, produce from Kerala is utilised for the purpose. 40 per cent of the production of tapioca of Kerala (which contribute about 90 per cent of the total production in the country) is utilised for sago and starch manufacture. As the total production for the country as a whole will rise considerably in future, the quantity available for industry even at 40 per cent will be large and, therefore, the industrial utilisation of tapioca can be kept at this rate itself. The quantity needed at the turn of the century at the present rate will be 16 million tonnes. There is likelihood of exploiting potato and sweet potato also for processed edible products. Assuming that 5 per cent of production each of potato and sweet potato will be utilised by industry, the quantity required will be 1.5 and 0.5 million tonnes respectively.

(iv) Export : A margin of 5 per cent of the total production from these crops can be earmarked for export. This will mean 4.0 million tonnes.

23.2.20 On the above basis, 47 million tonnes of tubers (potato 21, sweet potato 8 and tapioca 18 million tonnes) will be available for human consumption in 2000 AD. The carbohydrate content of potato, sweet potato and tapioca is 23, 28 and 38 per cent respectively.[1] On this basis these three crops will be able to supplement cereal diet to the extent of 14 million tonnes. In terms of per capita consumption it would mean about 15 kg per annum in terms of cereal equivalent or 50 kg in terms of the fresh weight of tubers. The per capita annual consumption of fresh potato in many European countries is more than 100 kg (Germany 174 kg). The present per capita consumption of potato in India is about 4 kg per annum; even with

[1] 1971. Gopalan C., *et al*, Hyderabad. Nutritive Value of Indian Foods. 2 p. National Institute of Nutrition, Indian Council of Medical Research.

the addition of sweet potato and tapioca, the picture will not be materially different. As against this the future possibilities of production of all the tuber crops might result in improving the per capita consumption by more than ten times. It is, therefore, necessary to have a vigorous extension drive on the one hand and a research programme to develop various kinds of palatable recipes on the other. The home science colleges in general and such colleges or divisions of the agricultural universities in particular could undertake the required research. The guidelines for research could be provided and coordination among the various institutions effected by the ICAR. The Departments of Agriculture at the Centre and in the States could undertake a coordinated programme of publicity through press, audio-visual means and public contact in *melas, bazars* and other places of congregation. Practical demonstrations of taste and preparation of recipes could also be held with advantage.

3 BULB CROPS

Onion

23.3.1 The widely known bulb crops are only two, viz., onion and garlic and these are considered here. Onion is popular throughout the country with the poor and rich alike. Being rich in proteins, minerals and vitamins, it is an important item in the diet of the poor. Its tender bulbs and shoots are cooked and commonly eaten in season as a vegetable. It also contains an essential oil, the chief constituent of which is allyl-propyl disulphide. The characteristic pungency of onion is due to this compound. Onion has many medicinal uses also. It is considered to have cooling properties and, therefore, it is used in the countryside both as a protective as well as a cure against heat-stroke. Freshly expressed onion juice has moderate bactericidal properties. Because of multi-faceted uses, the popular appeal for onion will ever remain undiminished and increase in its production within reasonable limits will not ordinarily pose a problem of disposal. Moreover, a good export demand for this commodity is likely to develop. Preference in European markets is for light golden (white flesh), mild flavoured, medium bulbs, which India does not produce in abundance at present but the production of which needs to be planned in the future. There is also scope for export of onion from India to African countries. A plan for increased production and raising the share of export even up to 25 per cent of production i.e. two and a half times

the existing level is therefore justified.

23.3.2 What has been stated above relates to onion in fresh form. Onion in dehydrated form also affords increasing opportunities. It has a high demand in the army and equally for export. There is substantial unutilised installed capacity available in the already established dehydration units in the country. A load of 5 per cent of production can easily be handled by these units. Non-availability of suitable varieties, however, is going to prove a bottleneck. White onion, which is in short supply, is preferred in the importing countries. The dehydration ratio of the existing varieties is low, because of which the recovery is poor. The aim should be to develop such varieties which will give maximum outturn on dehydration and yet possess other desirable qualities like colour, size, pungency etc. Manufacture of pickles, sauces, ketchups, *chutneys* also affords a promising field for enlargement of production. For pickling, small, silvery-white onions are popular, but these are not sufficiently produced in the country. Such varieties have also to be made available in requisite quantity.

23.3.3 At present statistics of area under the crop is reported by the DES. Data on area as well as production are available for the years 1957-58 to 1961-62 in the report entitled "Marketing of Onion in India" issued by the Directorate of Marketing and Inspection in 1966. In the absence of reliable estimates for more recent years, we have to go by the data in the DMI Report. However, for the future, it is necessary that an arrangement should be made whereby such data becomes available through sample surveys at least once in every five years.

23.3.4 A comparison of area under onions in different States during the periods 1957-58 to 1961-62 and 1968-69 to 1970-71 is made in Appendix 23.3. The crop is grown more or less in every State. The area has undergone changes of varying extent in different States. There are three cases of significant increases, viz., Maharashtra from 22 to 40, Bihar 4 to 14 and Orissa 8 to 19 thousand ha. In all, there is an increase of about 46,000 ha for the country as a whole. On the basis of the two sets of data, the peninsular States of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu together with Orissa can be taken to constitute the main region responsible for about 70 per cent of the all-India area. Maharashtra is the most important single State. As in the case of area, the production and yield rate must also have undergone changes overtime. It is very difficult to hazard a guess in this respect in the absence of data. However, on the basis of outdated data, a broad idea of the yield levels can be had from the figures given on the next page.

States	(tonnes/ha) yield
Maharashtra and Gujarat	15
Karnataka and Orissa	5
Other States	10
All-India average	10

Yields in Orissa and Karnataka are very low. The crop is usually irrigated, but it is taken under unirrigated conditions also in these two States. Attempts are necessary to raise their yield levels.

23.3.5 Other countries record yields of the order of 20—30 tonnes/ha. These are not difficult to be achieved within this country if one considers that even at present, when the crop is neglected, yields of the order of 15 tonnes per ha have been achieved. At present, there are no set varieties of agronomic standards. Present varieties are vaguely called (a) as *desi* and imported or (b) by the size as giant, large, medium and small or (c) by colour and name of associated place like Patna Red, Patna White, Poona Red, Nasik Red, Bellary Red etc. In fact, all these do not necessarily show any general criterion of distinction. Onion is an introduced crop and was imported in the beginning from countries like Spain, Portugal, Italy, Australia and the USA. Being highly cross-pollinated in nature, varieties got mixed up and what is in circulation is by and large a resultant of this process. The situation has to be rectified, varieties screened and desirable characteristics introduced. Needed characteristics for export and processing have already been mentioned. The north Indian States have a preference for pungent varieties. Rajasthan prefers yellow onion. Whatever little white onion is grown (5 per cent area under onion) is chiefly grown in Maharashtra, Karnataka and Tamil Nadu and, therefore, perhaps there is some consumer preference for it in these areas. Otherwise, red onion is popular throughout. Proper analysis of constituents and colour and consumer preferences in different States has to be made in a systematic manner. Varieties have also to be adapted to different agroclimatic needs. It will be necessary to enrich germ plasm through exotic collection. This will help in hybridization work also. Botanical studies will have to be undertaken for finding out optimum conditions of flowering, pollination and seed-setting. Agronomic and plant protection schedules also require to be developed.

23.3.6 Research and developmental activities on onion have so far been sporadic in nature. Regular and systematic attempts are needed. Because of the intensive attention needed by the crop, which will vary from place to place due to various factors like soil, irrigation,

agroclimatology, pests and diseases and because of differences in taste and choice, an all-India approach does not seem to be tenable for this crop. Each State must arrange to solve its own research and developmental problems. It will be a desirable step, however, that the major producing States of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu and Orissa may from some inter-State consultative machinery for mutual benefit. With necessary backing of research and developmental activities, it should be possible to double the existing yield level by 2000 AD to 20 tonnes/ha. Keeping the area stable at the present level of 160,000 ha, the total production attainable by then will be 3.2 million tonnes.

Garlic

23.3.7 The use of garlic is made in general as a condiment except for in-season use of leaves and tender bulbs for cooking or in raw form as *chutney*. It has many medicinal properties. It is considered to be heat-producing, whereas onion is cool. It is good for many stomach ailments and for rheumatism. It has an essential oil which contains allyl-propyl disulphide, di-allyl sulphide and two more sulphur containing compounds whose composition is not fully understood. As garlic has some more special principles (onion has only one), it is more pungent and has a different flavour. The anti-bacterial properties of garlic are due to allicin. The use of garlic in medicine has been limited in the past due to its smell and pungency. Successful attempts have been made recently in the Central Food Technological Research Institute, Mysore, to prepare garlic concentrate containing the precursor of the active principle to facilitate administration. The enzyme which activates the precursor is supplied separately in a capsule along with the syrup. Such a procedure will increase its use in future. Garlic is already used as flavouring agent in the manufacture of sauces and ketchups. Some pharmaceutical firms in India sell garlic powder in the form of tablets for use in stomach disorders and rheumatic troubles and it is likely to be accepted in increasing quantities in foreign markets too.

23.3.8 At present India exports annually about 2,000 tonnes of garlic in fresh form (2 per cent of the total production). Sri Lanka is the biggest buyer of Indian garlic, accounting for 73 per cent of the exports. It is exported in small quantities to many African, European, Middle-East, South-East Asian and American countries. Garlic is being popularised in some of these countries in various new food preparations like garlic salt, garlic vinegar, garliced potato chips, garliced bread and garliced meat tit-bits. The needs of export and processing industry may go up to 10 per cent of production in future.

The major importance of this crop will continue to lie in its consumption within the country as an item in food preparations. It would be possible to meet this demand from the present area under garlic by improving productivity levels to the extent possible. The available data pertain to the years 1961-62 to 1965-66. The total area under garlic in the country was 25,000 ha. About 60 per cent of the area was in the States of Madhya Pradesh, Gujarat, Maharashtra and Karnataka more or less in equal proportion and 70 per cent of production came from these States. The yields, however, showed great disparity among States (Karnataka 2, Madhya Pradesh 3, Maharashtra 6 and Gujarat 9 tonnes/ha). Other States accounted for between 4 and 8 per cent of the country's area under the crop with yields usually of the order of 2 tonnes/ha with the exception of Uttar Pradesh and Tamil Nadu, where the yields were 6 tonnes/ha. The average yield for the country as a whole was of the order of 4 tonnes/ha. The aim should be to raise the yield to 10 tonnes/ha by all possible means of improvement : varietal, agronomic, plant protection and developmental.

23.3.9 The variations in yield are a pointer to local variations and, therefore, underline the need for specific approach to problems from region to region or State to State. There is no recognised variety of garlic in the country. The names Mexican and Italian attached to some varieties suggest that their parents were introduced from these countries at some time or the other. Many types are known by either the colour of the skin (white or pink) or by that of the flesh (pure white and the pale-yellow). Preferences are noticed in some places for local pink types which are more pungent and are associated with high medicinal value. In other places, where dehydration is done, people prefer types having pure white flesh. The research and developmental problems of garlic are of the same nature as in the case of onion and our recommendations are in principle the same as enunciated there.

4 VEGETABLES*

23.4.1 Statistics regarding vegetables are available only for area. Averages for the period 1968-69 to 1970-71 indicate the following broad position :

(i) total area under vegetables is 0.90 Mha;

(ii) area ranges between 10—30 thousand ha in each of the States of Jammu & Kashmir, Punjab, Haryana,

*other than tubers and bulbs.

Rajasthan, Gujarat and Tamil Nadu;

(iii) area ranges between 30—50 thousand ha in each of the States of Assam, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Kerala; and

(iv) area ranges between 75—90 thousand ha in each of the States of Uttar Pradesh, Bihar and West Bengal.

The area reported for Orissa is 274 thousand hectares, which is disproportionately higher than other States. Obviously, this seems to be due to some lacuna in reporting. Corresponding production statistics are not reported annually. A pilot sample survey was conducted recently by the Institute of Agricultural Research Statistics for estimating the area and production of different vegetable crops.[1] The survey revealed that collection of data for vegetables was beset with difficulties because of various factors like short duration of crops, continuous sowing and harvesting and multiple pickings. Even then, the study struck a hopeful note in that it was possible to collect such data on vegetables by using sample survey techniques. It is worth considering how best this could be done at least periodically, if not annually. Besides, the cultivated vegetables, there are many kinds of wild plants whose leaves, stems, floral buds, flowers or raw fruits are consumed in the countryside on an appreciable scale in the seasons of availability. It will be interesting to make an exhaustive catalogue of such vegetation through suitable surveys and encourage the growth of most useful ones in cooperation with the forest departments.

23.4.2 It is difficult to hazard a guess on production in the absence of data. For meeting nutritional needs for moderate work per adult requirements of vegetables are put at 200 g/day.[2] Chapter 9 on Nutrition gives various patterns of improved diet at moderate cost. The rice based south Indian diet contains a provision for 160 g of vegetables per day, whereas the value for north Indian wheat based diet is 180 gm. At 180 g/day, the quantity needed in 2000 AD for the adult equivalent of the population will approximate 50 million tonnes and at 200 g/day it will be 55 million tonnes. Besides direct human needs, the country has also to make provision for export as well as processing. Fresh vegetables have been exported to UK and some of the neighbouring countries like Kuwait, Bahrain Islands, Nepal, Qatar and Dubai. The average annual exports between 1969-70 and 1971-72 have been of the order of 3,300 tonnes. Dehydrated peas, ketchups, sauces, juices and canned vegetables are already consumed to some extent by the urban population and are much in demand in the armed forces. About five dehydration units are working

1 1973. Sukhatme B.V. *et. al.*, Survey on Vegetables in Rural Areas of Delhi; New Delhi, Institute of Agricultural Research Statistics (ICAR).

2 1972. Gopalan, C. *et. al.* Nutritive Value of Indian Foods; Hyderabad, National Institute of Nutrition, Indian Council of Medical Research.

at present and 8 more are expected to come up. This is expected to raise the total installed annual capacity to 15,000 tonnes. There are a dozen canning units at present and the average production of canned vegetables is of the order of 6,000 tonnes. The annual exports of canned products has been about 200 tonnes. This could be considered as a good beginning for utilization of vegetables for export or processing and the need for these purposes is definitely going to rise in future. In addition, an allowance is also necessary to be made for spoilage, which is substantial in a perishable commodity like vegetables. Considering these factors, one can plan for an *ad hoc* production of about 80 million tonnes by 2000 AD, which would account for an area of 4 Mha, assuming an average yield target of 20 tonnes/ha. Fifty per cent of this area could be expected to be under irrigation.

23.4.3 Vegetable cultivation in the country follows two broad patterns, viz., (a) what is grown in the interior villages and (b) what is grown in the suburbs of towns and cities. Most of the villages, which are not easily linked with towns and cities, do not grow the perishable kinds but vegetables like pumpkins, which can be stored for a long time even under ordinary conditions without any deterioration. They also sometimes grow semi-perishable articles like colocasia and potato. Many other cucurbits like bottlegourd, cucumber, bittergourd (*karela*), ridgedgourd (*taroi*) and melons are also grown on borders or between rows in the field or trailed along their huts. Brinjal, lady's fingers and cluster beans are also grown. These are for domestic consumption and are also often carried to periodical village *haats* for sale. Vegetables of kinds other than those mentioned above have not been produced by villages to any significant extent just because of the lack of means of communication. A variety of vegetables were contemplated to be grown in villages in different Community Development Blocks as a part of the Applied Nutrition Programme since 1962, in collaboration with the UNICEF, FAO and WHO. The idea has been to encourage people to grow vegetables in the backyards of their homes to meet their nutritional needs. Out of a total number of 5,092 blocks in the country, the number covered till March, 1973 was only 1,093,[1] or 21.5 per cent in a period of 10 years. Although the programme was primarily meant for raising the nutritional standard of village people, the slow pace can be taken to be an indication of their inaccessibility to markets, because they consider every measure from the viewpoint of earning money rather than a mere improvement in their health standards. The position is expected to change when the marketing centres come up within every 5 km radius, which will facilitate the disposal of perishable commodities

1 1972-73. Special Programmes in Community Development, New Delhi. Ministry of Agriculture, Government of India.

produced in villages. This measure has been contemplated in Chapter 56 on Marketing, Transport and Storage. It will then be possible for every village to get involved in the production of vegetables.

23.4.4 Suburban cultivation of vegetables represents the traditional pattern of vegetable culture (olericulture) in India. Its special features are as follows :

(i) It is practised by a hereditary class of growers known as *kachhis* or *barahmasis,* who dwell around towns and cities.

(ii) The holdings used for vegetable growing are almost permanently fixed as far as site is concerned. These are very small, measuring only a few cents of a hectare.

(iii) The lands are wholly irrigated. Except for bigger towns where it is now possible to use better devices, percolation wells or tanks or nalas are generally used for irrigation according to the needs of different situations and the operational devices are mostly manual or bullock driven.

(iv) The vegetable holdings being fixed, there might be rotation between different kinds of vegetables, but a rotation with other crops is usually ruled out. Therefore, relay cropping predominates and at any one time there might be even a mixture of crops standing in the same plot, e.g., a leaf crop may be taken around the bunds and irrigation channels and within the plot, there might be brinjals and in between the rows of brinjals there might be a root crop.

(v) The method of cultivation is, therefore, naturally intensive, where there is no room for rest to the soil. Except for bigger cities, usually the level of manuring is not adequate. Application of cowdung and ash, which are derived from the household, is most usually resorted to.

(vi) Continuous use of the same piece of land season after season and year after year makes it a harbouring ground for various kinds of pathogens and pests. Effective plant protection measures are usually missing.

23.4.5 The belt around an urban area, which grows vegetables, is narrow for the smaller towns but its width goes on expanding as one goes to bigger cities. Besides such vegetable belts around every town and city, the urban areas also draw their supplies from far off places. Cities of medium size draw their vegetables from nearby towns but metropolitan cities get supplies from much longer distances. For example, Calcutta draws its supplies of vegetables from Bihar, Uttar Pradesh, Madhya Pradesh and even from places as far off as Simla. Bombay draws its supplies from Nasik, Poona or even beyond

and from many far off towns of Gujarat. Delhi draws into its ambit many areas of Haryana, Punjab, Rajasthan and Uttar Pradesh. Ahmedabad gets its supplies from Nasik, Bombay, Jaipur, Mathura, Meerut and Agra. Nagpur also gets its supplies from Nasik and Poona. One has to concede that vegetable growing will continue to be concentrated around towns and cities in future. For the sake of calculation, one can consider that the hinterland lies in a radius of 40 km for the metropolitan and capital cities, 25 km for the medium sized cities and towns and 10 km for the smaller ones. Assuming the gross cropped area on an average to be about half of the geographical area and assuming that vegetables will occupy 10 per cent of the cultivated area around big cities of the first category, 5 per cent of the next category and 1 per cent of other towns, the total area requirements for vegetables will be of the order of 2.8 Mha.

23.4.6 The vegetable belts around cities and towns will require better and efficient methods of vegetable production. Manures and irrigation are going to be the primary requirements for a successful programme. The organised sewerage system, which functions in most of the big cities and towns, can prove very helpful in this regard. Effluent flowing from this system serves the double purpose of providing irrigation as well as some of the required manurial ingredients in soluble form. Places like Poona and Delhi have a special canal or pipe system to make available such effluent water for cultivation. This type of service has to be developed in a systematic manner in every city and town. Moreover, the sludge obtained from this system is substantial and a very effective source of soil enrichment. The Committee on Urban Wastes (1971), Ministry of Works and Housing, Government of India conducted a survey of the quantity of nightsoil, refuse and other wastes handled by the local bodies having a population of 5,000 to over 100,000. On the basis of this survey, the availability of sludge works out to about 318 kg per capita per annum and assuming even half of this quantity to be available to growers as manure, the total quantity which will be available in 2000 AD from an urban population of about 273 millions will be of the order of 40 million tonnes. This entire quantity is required to be fully utilised and it should be the responsibility of the local bodies to encourage maximum possible use of this source for vegetable production.

23.4.7 Handicaps of present day cultivation of vegetables have already been stated in some of the foregoing paragraphs. The individual holdings are very small, because of which many modern mechanised methods cannot be followed. However, there is one advantage that all the vegetable growers usually have their plots contiguously situated. Hence the plots can be constituted easily into suitable blocks for major collective operations like dusting, spraying and tractor ploughing etc.

It has to be recognised that individual growers will not be able to conduct such operations because of their limited holdings as well as inadequacy of finances. It should be the responsibility of the State Governments through their Departments of Agriculture/Horticulture to organise the growers into suitable cooperatives so that they can derive the benefits of collective measures. It should also be the responsibility of the Governments to see that proper facilities for various kinds of operations are placed at the disposal of the growers in the form of custom service. The custom service can be organised either through cooperatives or through governmental organisations. As far as irrigation is concerned, the State Governments will have to ensure that the entire vegetable area is duly commanded by canals or wells. Wherever the plots are at a distance from a canal, the growers should be encouraged to sink wells on a joint ownership basis. The Governments should render all possible help by providing guidance, material and finances for this purpose.

23.4.8 The vastness of the country covering various agroclimatic regions permits growing of every kind of vegetable and with the development of rapid means of communication, it has become possible to make available vegetables from one part of the country to the other. The concentration of vegetable belts around cities serves both the purposes, viz. (a) of meeting the immediate needs of the city concerned and (b) supplying to other distant cities the vegetables which though 'in-season' at the place of production are 'off-season' for the others. Then, with the development of rail and road transport systems, it is possible to make available the vegetables which are grown at higher altitudes to cities in the plains all through the year, e.g., tomatoes, capsicums (vegetable chillies), cole crops, lettuce, turnips, carrots and beetroot. In this latter context, production of vegetables in the high hills of Kashmir, Himachal Pradesh, west Uttar Pradesh, Himalayan West Bengal, Central Plateau (Mount Abu, Pachmarhi, Hazaribagh and Ranchi), the Western Ghats and Nilgiris (Mahabaleshwar, Ooty, Kodaikannal, etc.) assumes special importance. Such areas have been used in the past chiefly for seed production, but now they can participate in vegetable production programme for making supplies to plains also. An area of about 200 thousand hectares can be earmarked to be developed in such places.

23.4.9 An area of about 3 Mha is already accounted for in the development of vegetable belts around cities and towns or in the hills which is also meant to mainly cater to the needs of urban population. The remaining 1 Mha of the total proposed area of 4 Mha can be mainly earmarked for the production of vegetables in the interior and in this preference could be given to sites situated in the vicinity of lakes, tanks, rivers and canals. We have already stated in Chapter

21 on Foodgrain Crops that rice crop has to be withdrawn from the peripheries of tanks and lakes, where water cannot easily reach through flow irrigation. Such areas, which have to depend on lift irrigation, can be transferred to other crops among which vegetables would figure prominently. Riverbeds are being utilised to some extent even now for growing vegetables, but not the canal beds. There is the problem of waterlogging along the canals. Perhaps this situation could be retrieved to a great extent by resort to vegetable growing. An area of about 0.8 Mha could be earmarked in this manner. The balance of the area of about 0.2 Mha could be accounted for by kitchen gardens in the cities and towns and even in the interior villages. Kitchen gardens are already becoming popular in towns and cities and it has already been mentioned that attempts are being made to popularise them in villages through the Community Development Blocks. If progress is to be judged by the number of families who have taken to kitchen gardening and the permanency of the kitchen gardens already established in rural areas as a part of this scheme, perhaps the picture will be still more discouraging. One common factor, which, of course, applies equally to most of the areas under vegetable cultivation is the constraint of supplies of seed, fertilisers, and plant protection chemicals being within the means of the small growers. The other constraint is that of transport. As regards the first, the remedy lies in encouraging the sale of the required inputs in minikits, which will be within the reach of an ordinary grower. To overcome the second constraint, the programme of extending vegetable cultivation to the interior will have to be undertaken in pace with the development of roads or other means of communication. This makes it necessary to draw priorities for extending the area. Towns and cities should get the first preference; next in order could be the hills; then beds of tanks, lakes, rivers and canals and lastly the interior villages. Priorities within the urban areas could be in the following order :

(i) vegetable belts around metropolitan towns;
(ii) vegetable belts around State capitals;
(iii) vegetable belts around district headquarters;
(iv) vegetable belts around taluk headquarters; and
(v) development of kitchen gardens simultaneously.

23.4.10 Examining the scientific content in the prevailing materials and methods of vegetable cultivation, one will find that most of the vegetables have no standard varieties. All sort of good and bad material is grown everywhere. A few vegetables like tomato, brinjal, cole crops, chillies, beans, spinach (*palak*) have received some attention, but the requirements of various areas and tastes are so different that the existing varieties are not sufficient to meet the

needs. There is a lack of knowledge and practice of scientific vegetable cultivation among growers in respect of time of planting, optimum plant population per hectare, composition and dosage of manures and fertilizers, irrigation, utilization of pesticides, insecticides and hormones. Pests and diseases are rampant everywhere. Virsuses, wilts, physiologic disorders and fruit flies, borers, cutworms and nematodes are most common. There always existed a poor base for vegetable research. Ordinarily, agricultural colleges had a small section dealing with vegetables either attached to their agronomy or horticulture division and there also much attention could not be paid to it, because the persons put in charge of such work had to do many other jobs too and these other jobs were considered more important than attending to vegetables. Some private firms dealt with research work on vegetables (specially, the temperate ones) but this was only notional. What they did was to import seed of some of the varieties, multiply it in suitable locations like the high hills of the north and south and sell the same at high prices.

23.4.11 Agricultural universities were established in various States after 1960. Though these were expected to look after vegetable research, but the expected importance and impetus still remains to be developed. In fact, by virtue of various kinds of diversities pertaining to soil, climate, orography, irrigation facilities and consumer taste in the choice of vegetables, vegetable research has to be highly localised and in this respect agricultural universities have to play an important role. At the Centre, a Division of Horticulture was organised at the IARI during the Second Five Year Plan period. It was only in 1971 that this Division was split up into two separate parts—one dealing with horticulture and fruit technology and the other with vegetable crops and floriculture. The Division of Vegetable Crops and Floriculture has two substations at present, one at Katrain in Kulu Valley dealing with temperate crops and the other at Karnal dealing with subtropical and tropical crops of vegetables. There is a Vegetable Research Section also at the IHRI. Lately, an all-India Coordinated Vegetable Improvement Project has also been started with a coordinating cell at the IARI. The work under this project is carried out at a network of 17 stations spread in different parts of the country. These represent some most recent steps the impact of which will be felt only with the passage of time.

23.4.12 The developmental activities pertaining to vegetables have no distinct *locus standi*. These have usually been clubbed together with the setup meant for the major field crops with the result that vegetable growers have failed to attract due notice. This position will be automatically rectified to a great extent in future, when horticultural staff has been provided upto *taluk* level and agricultural staff

becomes available upto the Block or Circle in accordance with our general recommendations. The growers need attention in various directions. As stated carlier, they have to be organised collectively for various kinds of field operations, which can be done only in vast chunks of area. It will be a big step forward if a system of beneficial rotations or companion cropping could be introduced in vegetable plots from the soil point of view and legumes would suit most ideally for this. For rotation, many short statured beans could be introduced which usually form part of vegetable recipes. In companion cropping, berseem and lucerne can fit in most profitably, because these would fetch good price for the growers at any time of the year. The production programmes will have to be given an orientation with an eye on the needs of processing industry also. A few examples are given below :

(i) Tomato : Tomato is used for processing as 'canned whole', juice, sauce and concentrates. Of late, general opinion has developed against the use of colour in tomato products. Several countries including India have already prohibited the use of colour. Another important point relates to the recovery percentage of juice, which has a bearing on the total solids. The essential requirements of the tomato juice processing industry, therefore, are (a) varieties with fruits of natural deep red colour and (b) high percentage of solids. Similarly, for canning, the fruits should retain attractive red colour and remain firm and not get pulpy when peeled and canned.

(ii) Cauliflower : Compact heads white in colour are specially suited to processing.

(iii) Chillies : These are used for pickling as stuffed chillies. For this, medium sized, thick-skinned but bold chillies of deep colour are preferred.

These illustrate the special needs of the processing industry, but some sort of system is required to be developed even in general whereby it becomes possible to lift the surplus quantities from markets for processing purposes in order to prevent distress sales forced by the perishable nature of the commodities.

23.4.13 The growers are also required to be encouraged to grow vegetables from the export point of view. As mentioned in Chapter 12 on Export Possibilities and Import Substitution, the Indian Institute of Foreign Trade, after a survey (1968) in 22 countries of the world to assess India's export potential of fruits and vegetables, reported that excellent market opportunities are available in Europe, West Asia and South East Asia for the export of cauliflower, cabbage, frenchbeans, garden peas, capsicum, lady's finger, brinjal, tinda (*Citrullus*

vulgaris), parwal (*Trichosanthes diocia*), bittergourd and yam. It was further considered that India had the requisite resource base to produce fresh vegetables and that market opportunities existed overseas and, therefore, it should be possible to reach an export level of 16,500 tonnes of fresh vegetables by 1975-76. The Indian Institute of Foreign Trade also reported that there was scope for increased exports of processed vegetables from India and fixed an export target of 10,000 tonnes of processed vegetables by 1975-76. It does not seem possible that these targets can be fulfilled, but it does indicate the future prospects of expanding vegetable cultivation. The country should be able to evolve the right kind of varieties for export with regard to colour, shape, size and taste which are preferred in foreign countries. For example, deep purple, roundish and long brinjals are preferred in European markets. There is a liking abroad for small podded varieties of lady's finger with less mucilage to be used as a canned product, etc. At present all kinds of produce is tried to be exported without regard to quality, which is not a healthy tendency, because once a prejudice is created in a foreign market, it will be difficult to push through even the best of material later on. The remedy against this lies only in producing the required type of material.

23.4.14 Techniques utilising the hybrid vigour are in use in all biological fields to boost production and the same can be done with advantage for the production of vegetables, especially for processing and export. The pace of utilisation of hybrid vigour in vegetable improvement has been rather slow in this country. The basic handicap in the past was the absence of a scientifically organised seed industry, which is a very essential step for maintaining the parental lines required in the multiplication programme. The picture has now changed and some seedsmen have already employed professional vegetable breeders for producing hybrids. The IARI, the IHRI, the Punjab Agricultural University, the Vivekanand Laboratories, Almora and the Institute of Agricultural Sciences, Kanpur are examples where some interest in hybridisation in recent times has been evinced. Crops on which the work has been in progress are onion, melons, bottlegourd, chillies, tomato, brinjal and cabbage, but the hybrids released are very few. Preliminary experience has indicated that hybrids released so far have created an impression among the farmers that these are very susceptible to diseases and pests and, therefore, their acceptance has been very slow. It has already been indicated that the plant protection measures are almost absent in vegetable cultivation and, therefore, all varieties—whether hybrids or otherwise—are equally exposed to and affected by the infestations. The impression of extraordinary susceptibility of hybrids alone does not seem to have much validity. However, it is necessary that disease resistant stocks are specially introduced in F_1

combinations when resistance is found to be governed by dominant genes. Further, in order to increase the acceptability of hybrids, it is necessary to choose such vegetables for this work where the farmer is not in a position to produce his own seed.

23.4.15 There are a large number of indigenous vegetables particularly leafy, on which no systematic studies regarding their nutritional values and agro-techniques have been done. Leafy vegetables being of high nutritive and protective value need special attention of the horticulturists. Leafy vegetables belonging to different species of ***Amaranthus, Portulaca, Trigonella, Aerva, Alternanthera, Basella, Celosia*** and various other species should be collected and evaluated for their nutritional and other desirable characters.

5 CONDIMENTS AND SPICES

Ginger

23.5.1 Every Indian household is familiar with ginger in the form of *sonth*. Its use in green form as an additive to vegetables or in salad is also quite common. It contains from 0.25 to over 3 per cent of a volatile oil of light yellow colour containing terpenes, cineol, citral and borneol, which impart to it a characteristic aroma. Its pungent taste is due to the presence of a resin found dissolved in the oil. Ginger is useful for various purposes, e.g., (a) as a spice in cookery, to give flavour to a wide variety of foods, (b) in confectionery and preserves (whether in a syrup or as crystalline ginger in the form of candy, cubes or flakes), (c) as pickled in salt and lime juice, (d) in distilleries for the preparation of ginger beer, ginger ale, ginger brandy and ginger wine, (e) in medicinal and veterinary preparations and (f) in the manufacture of ginger oil, ginger essence, ginger oleoresin (gingerene) and starch (from spent ginger). In India, however, its use for processed articles or industrial products is negligible at present. The main importance of ginger to the country lies in its export in dried form.

23.5.2 Area under ginger and its production (dry basis) are presented in Appendix 23.4—Statement I. The data generally relate to the period 1969-70 to 1971-72 except in the case of Assam and Bihar as explained in Appendix 23.4. Country's total production is only 34,000 tonnes and the area occupied by the crop is also small, viz., 27,000 ha. The production in most of the States is such that it can suffice only for local needs of ginger in fresh form. Kerala accounts for about 45 per cent and 54 per cent of all-India area and production respectively. The North-Eastern States together also account for a

substantial part of all-India area and production, viz., about 16 per cent. Both Kerala and Assam have high rainfall and humidity conditions and both seem to be favourable for ginger cultivation. Both grow such varieties of ginger, which are less fibrous than those which are prevalent in other parts. However, Kerala has specialised in producing dried ginger, i.e., *sonth*, whereas Assam has not. It is likely that export facilities are responsible for this difference. Kerala is the only State which exports dried ginger to outside countries. It also provides dried ginger to other States.

23.5.3 A study of international production and export data as reported in different publications[1] does not give a clear picture of the order of importance of various countries in production and export of ginger. However, it is certain that India produces and exports the largest quantity. African countries of Nigeria and Sierra Leone seem to be fast catching up. Indian export has shown fluctuation over years. Despite this, the Middle East countries accounted for more or less half of our total exports. A peak of export of 10,000 tonnes was attained in 1957. The fluctuation has generally been around 3,000 tonnes the exceptions being 1968-69 and 1969-70 when the quantities exported were less than 2,000 tonnes. The year 1971-72 once again showed a rise in exports viz., 7 thousand tonnes followed by 6 thousand tonnes in 1972-73 and 5 thousand tonnes in 1973-74. The Marketing Research Corporation of India conducted a survey of India's export potential of spices in 1968. It was found that the high prices of Indian ginger severely erode her place in the two most important markets in the west—the USA and the UK. In addition, even India's guaranteed markets in the Middle East get affected by higher prices. Secondly, Indian ginger has higher fibre content and is usually rough-peeled and is, therefore, in less demand in competition with Jamaican or Sierra Leone gingers. There is need to concentrate on evolving such fibreless varieties which have a demand in the foreign markets. The fibreless characteristic has also to be combined with the high yield.

23.5.4 The 'Rio de Jeneiro' variety is a very high yielder (twice or thrice the yield of prevalent varieties). It has a higher fibre content when compared with the Kerala varieties, but in comparison to varieties found in other States, it has less fibre. It is not fit for export, but can suit well for internal consumption. However, this variety has gained popularity in Kerala. This is not a desirable trend from the export angle and Kerala will stand to loose if its production is not

1 (i) 1968. Production of Ginger in Major Producing Countries (1964-66)—Survey of India's Export Potential of Spices : New Delhi, The Marketing Research Corporation of India, Ltd.

(ii) India's position in the trade of ginger 1957-61, 1962-68, Commodity Division of the Commonwealth Secretariat, London (private communication, 1973).

(iii) Monthly Statistics of Foreign Trade of India, Vol. I of March 1968, 1969, 1970, 1971 and 1972, Calcutta, Directorate General of Commercial Intelligence & Statistics.

discouraged. In order to avoid this situation the growers in Kerala have to be educated that they should not go by the yield standard alone and should continue to give due regard to quality also. There seems to be no harm if cultivation of this variety is popularised in States other than Kerala for internal consumption purely as an immediate interim measure in order to derive the advantage of its higher yield potential, but even then popularising the least fibrous varieties in all the States should be considered the goal.

23.5.5 Kerala is the leading State in the production of ginger. It is desirable, therefore, that maximum attention on research activities is focussed in that State. The States of north-eastern part of the country are important for ginger next only to Kerala both in quality and quantity of production and, therefore, their collaboration with Kerala in all research and developmental activities will be a step in right direction. In fact, all steps should be taken whereby the North Eastern Region could make its due contribution in meeting the internal and external demand for this commodity. With proper research, the yield can reach 2.5 tonnes/ha, i.e. nearly double of the existing level. This will result in a production of about 70,000 tonnes. It will be then easy to step up considerably the proportion of production for export and processing articles like beverages, candies and medicinal extracts. For successful commercial exploitation, ginger research stations will have to determine the optimum stages of maturity necessary for different purposes like the manufacture of ginger preserve in syrup, candy, oleoresin and essential oil etc.

Turmeric

23.5.6 Cured rhizomes of *Curcuma longa* mainly constitute the commercial variety of turmeric. Another species (C. *amda*) is also grown to some extent in India. It is popularly known as *amba haldi* (mango turmeric), because its rhizomes possess the smell of green mango, when fresh; it is used for pickles in the south. Turmeric contains about 2.0 per cent of curcumin dye, because of which it is used for colouring textile fabrics. However, with the introduction of cheap aniline dyes in place of the vegetable dyes, the use of turmeric as a source of dye has become very much limited. Turmeric also contains an essential oil, which is extensively used in confectionery and aerated water industries. Next to ginger oil, turmeric oil appears to be the most suitable source of zingiberene. Turmeric possesses stomachic, tonic, blood purifying, anthelmintic, antacid and carminative properties. Of all the uses, the most widespread use is as a condiment. It is an indispensable article for flavouring and colouring of various kinds of dishes and in the preparation of pickles. Utilisation percentages of

turmeric for various purposes are : medicinal, 1.5, dye, 2.5; cosmetics, 6.0; and seed, 17.7 of the total production.[1] Besides these uses, turmeric is also exported. Exports during the five years ending 1971-72 ranged between 6 and 14 thousand tonnes, the average being 9,000 tonnes, i.e. about 6 per cent of production. Making an allowance of 5 per cent for wastage etc., the quantity utilised for domestic consumption could be taken as 60 per cent.

23.5.7 The total area under turmeric and production of cured turmeric was 76,400 ha and 143,000 tonnes respectively during the triennium ending 1971-72. The important producing States are Bihar, Orissa, Maharashtra, Andhra Pradesh and Tamil Nadu. The cultivation of turmeric in Punjab, Haryana, Rajasthan, Gujarat and Madhya Pradesh is much less than in other States. Statewise data are given in Table 23.2. Andhra Pradesh and Tamil Nadu together account for 60 per cent of all-India production. Andhra Pradesh is the leading State both as regards area and production of turmeric. However, yield is the highest in Tamil Nadu, viz., 3.8 tonnes/ha and in Andhra Pradesh yield is only 63 per cent of that in Tamil Nadu. If the yield target for both Andhra Pradesh and Tamil Nadu in 2000 AD is kept at 5 tonnes/ha and for other States at 2.5 tonnes/ha, and if the all-India area target is put at 76,000 ha without any change in the area under turmeric in Andhra Pradesh and Tamil Nadu, the total production by the turn of century works out to 267,000 tonnes, which will imply an average yield of 3.5 tonnes/ha for the country as a whole. The onus of primary research work on the crops should lie jointly with the States of Bihar, Orissa, Maharashtra, Andhra Pradesh and Tamil Nadu.

TABLE 23.2

Area and Production of Cured Turmeric
(Average of 1969-70 to 1971-72)

Area = thousand ha
Production = thousand tonnes
Yield = tonnes/ha

	Area		Production		Yield
	Actual	Per cent	Actual	Per cent	
Bihar	8.7	11	13.1	9	1.5
Orissa	12.3	16	14.9	10	1.2
Maharashtra	9.6	13	12.2	8	1.3
Andhra Pradesh	21.6	28	51.0	36	2.4
Tamil Nadu	9.3	12	35.1	25	3.8
total	61.5	80	126.3	88	2.05
all-India	76.4	100	143.0	100	1.87

1 1965. Marketing of Turmeric in India, Nagpur. Directorate of Marketing & Inspection, Ministry of Agriculture & Irrigation, Government of India.

Chillies

23.5.8 Green chillies are an integral part of vegetable preparations throughout the country. These constitute an essential accompaniment to *bhakri, sattu* or parched grains for the working class. These are taken raw, cooked or in preserved form in lime juice, vinegar or oil and are a cheap source of vitamins C and A and minerals. There is a tendency to grow a few plants of chillies in every household; they are also grown in kitchen gardens and in small plots in vegetable belts throughout the year. Non-pungent, thick pericarped large, oblong or pear shaped varieties—generally called by the generic name itself as capsicums—are cooked like vegetables. Their cultivation is mainly concentrated in the hills, from where they are supplied to the consuming markets. There are no statistics on area and production of green chillies. Reported data pertain to only chillies which are dried, and which are mainly used as a seasoning, flavouring and colouring agent. Different varieties of chillies for drying are grown as regular agricultural crops in large areas. Such varieties possess highly pungent fruits with thin rind and comparatively smooth pericarp. Pungency of chillies is due to capsicin (0.1 per cent). The total colour pigments of chillies are of the order of 4-5 gm per kg of ripe chillies. Chillies in dry form are used in domestic medicines also. These are considered to possess stomachic and stimulant properties and are also used externally as a rubifacient. Dry chillies are also an exportable commodity. Sri Lanka was the largest importer of Indian chillies accounting for about 80 per cent of total export till 1971-72. In the subsequent years, however, it has stopped importing chillies from India resulting in a substantial decline in the exports of chillies. Export in the 3 years ending 1971-72 has ranged between 2,000 and 5,000 tonnes. It had ranged between 5,000 and 12,000 tonnes in the earlier nine years. In terms of production, the quantity exported has not exceeded 3 per cent.

23.5.9 Average area and production of chillies crop (for drying) are given in Appendix 23.4—Statement II. The area under chillies in the country is of the order of 700,000 hectares and production 450,000 tonnes. Almost all the States grow this crop, but important growing States are Andhra Pradesh, Maharashtra, Tamil Nadu and Karnataka. Tamil Nadu records the best yield, viz., 14 q/ha. The yield ranges between 3 and 6 q/ha in the other three States. Low yield of chillies is mainly due to high incidence of diseases like mosaic, leaf curl, die-back, wilt and fruit-rot. Among these, mosaic is the most widespread. Ninetyeight per cent of the varieties are affected by this virus disease and the incidence ranges from 70 to 92 per cent among the susceptible varieties.[1] If varieties resistant to the diseases mentioned above could

1 Aiyadurai, S.G., 1966. Ernakulam. A Review of Research on Spices and Cashewnut; p. 130, Regional Office (Spices & Cashewnut), ICAR.

be evolved and agronomic and plant protection schedules developed to control the menace, this can constitute the major single factor to increase the average all-India yield at least to twice the present level. The research work could be undertaken by the States concerned.

Coriander

23.5.10 Coriander is taken as a field crop for its fruit, commonly known as *dhania* and it is in this form that the maximum use of this spice is made. Due to their pleasant aroma, its tender shoots are also used in green form throughout the country for seasoning, *chutneys* and salads. For use in green form it is grown in vegetable plots by the *kachhis*. Coriander seeds are used in Gujarat, Maharashtra and other neighbouring areas as a masticant for improving mouth odour. The odour and taste of coriander is due to its essential oil, of which oleoresin is a constituent (5 per cent). In foreign countries, oleoresin is used for flavouring of beverages, confectionery articles or many other food delicacies. The use of oleoresin is not yet popular in India, but it would increase in future with the increase in the use of beverages, etc. At present, there are a few oleoresin manufacturing units in the country, e.g., at Madras, Calcutta and Kozhikode. The product is mainly meant for export at present. Coriander in fruit form is also exported from the country. The order of exports has been erratic in the last ten years. There is a need to study the reasons for these fluctuations with a view to devise measures to stabilize exports.

23.5.11 Area and production statistics pertaining to coriander fruit based generally on the data for the years 1969-70 to 1971-72 are presented in Appendix 23.4—Statement III. The data pertaining to Assam and Maharashtra, however, refer to the period 1961-62 to 1965-66. The total area under coriander in the country comes to about 280,000 ha and the production is of the order of 1,10,000 tonnes. The major coriander producing States are Rajasthan, Maharashtra, Andhra Pradesh, Madhya Pradesh and Tamil Nadu. The yield level in the country as a whole is of the order of 4 quintals/ha. Yield in Andhra Pradesh is only 2 quintals per ha. Coriander is known to suffer from wilt and downy mildew. If the incidence of these two diseases is eliminated by developing resistant varieties and if the crop is given due attention in research and developmental programmes in the major producing States, specially Andhra Pradesh, it is possible to increase country's production to twice the present level.

6 MUSHROOMS

23.6.1 Edible mushrooms are used as vegetable. Main chemical constituents of the common edible mushroom 'Agricus sp' are: protein, 3.5 ; carbohydrates, 6.8 ; fat, 0.4 and ash 1.2 per cent ; thiamin, 0.12 ; riboflavin, 0.52 ; ascorbic acid, 8.69 ; niacin 5.85 and pantothenic acid 2.38 mg/100 g.[1] The ash consists of minerals like iron, calcium, potassium, magnesium and phosphorus. Mushrooms are specially suited in diabetic or other conditions where low cereal intake is desired. Mushrooms are of various kinds and are either found wild or are artificially cultured. The important edible mushrooms are described below :

Wild types

(i) *Phellorina inquinans* and *Podaxis pistillaris*—both these species are sold in the market under one name, *khumbh*, because of similarity in resemblance. *P. inquinans* grows in sandy places chiefly in Rajasthan and Haryana. It is mostly sold in dried form. Some quantity is also available in fresh form in September, towards the end of monsoon season. *P. pistillaris* grows in soils rich in organic matter and appears in July-August after the rains. It is found chiefly in plains of Haryana and to a lesser extent in the surrounding areas of Punjab, Rajasthan and Uttar Pradesh.

(ii) *Tuber sp.* (truffles) is a black mushroom, which develops underground in symbiosis with oak roots. It is highly prized in West Europe. At present, it is known only locally in certain places like Kathgodam (Uttar Pradesh), but the entire oak belt in the sub-Himalayas offers promise for growing this mushroom.

(iii) *Morchella sp.* (*guchhi*) : *Pleurotus ostreatus* and *Chautervelle sp.* (*dhingri*)—these are typical of mountainous areas. *Morchella* is the only species which has received major attention in this country so far. It grows in the coniferous forests of high hills at elevations between 2,500 and 5,000 metres above sea level. It has been commonly known and used in the States of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh. It appears soon after the melting of the snow (March-April) and in the monsoon season (August-September). It is abundant in the years of heavy

1 Mantel, E.F.K. 1967. The Development of Mushroom Production and its Importance as Food in India, Proceedings of International Symposium on Sub-Tropical and Tropical Horticulture.

snowfall in forests which have been freshly cleared and have plenty of organic matter. It does not do well in congested and heavily shaded forests. Attempts made to produce it under artificial conditions have not succeeded either in India or elsewhere in the world. Its collection in the hills of Uttar Pradesh has not been taken up to any large extent. Its maximum exploitation is in Jammu and Kashmir followed by Himachal Pradesh. The Forest Departments of the States concerned auction collection rights on year-to year basis. Villagers also make their own collections. *Morchella* is sundried and preserved for domestic consumption or for sale. It is estimated that annually about 21 tonnes of dried *Morchella* in Jammu and Kashmir and 9 tonnes in Himachal Pradesh are obtained in this manner. Of this collection, about 80 per cent (i.e. 24 tonnes) is exported from the country earning a foreign exchange of Rs. 40 lakhs.[1] About 65 per cent of the average annual exports of dried mushrooms during the period 1967-68 to 1970-71 were effected to Switzerland, 15 per cent to France, 7.5 per cent to Bulgaria and the remaining 12.5 per cent to countries like German Federal Republic, Nepal, Japan, Poland, Singapore, Sweden, Thailand, UK, USA and Yugoslavia.[2]

Cultivated types

(iv) *Volvariella sp.* (tropical or paddy straw mushroom)—is commonly grown on fresh water-soaked paddy straw in sheltered places in the open, for instance, in fields under grapes, under mango trees or in banana plantations. It likes tropical conditions and is grown on a commercial scale in Indonesia and Philippines. The commercial production of this mushroom has not been taken up in India.

(v) *Lentinus edudes* (Shiitake) is artificially grown, but in an environment of live trees. Laboratory grown spawn is introduced into holes bored in the trunks of dead hard wood trees, the holes sealed with wax in order to prevent extraneous infection and the trunks placed in shade under live trees. Mushroom appears after two years. There are two crops per year and the progeny of an initial spawn can

1 1974. Marketing of Mushrooms in India, Marketing Series No. 187, Faridabad, Directorate of Marketing and Inspection. Ministry of Agriculture & Irrigation, Government of India.

2 Monthly Statistics of the Foreign Trade of India, Vol. I of March 1968, March 1969, March 1970 and March 1971. Calcutta, Directorate General of Commercial Intelligence & Statistics.

last as long as six years. This is common in China and Japan. This technique is only in a preliminary experimental stage in this country.

(vi) *Agaricus bisporus* (button, white European or temperate mushroom)—is grown on compost in specially constructed mushroom houses. This is the only cultivated mushroom which has been exploited commercially in the country. During the last few years, cultivation of *A. bisporus* has developed in Kashmir valley, Himachal Pradesh (Chail, Dochi, Kasauli, Taradevi and Solan), Uttar Pradesh (Mussoorie and Bhimtal) and Tamil Nadu (Nilgiris). Delhi and Patiala have also started growing it during winter months. Production figures for *A. bisporus* for 1970-71[1] are of the following order in terms of fresh weight :—

State	Annual production (tonnes)
Himachal Pradesh	70
Jammu & Kashmir	30
Punjab	15
Delhi	6
Tamil Nadu	10
	131

This mushroom can be grown in winter months in many other places in the plains of India.

23.6.2 It would be clear from the foregoing description that only two kinds of mushroom have been exploited in this country so far, viz., *Morchella* and *Agaricus*. About 6 tonnes of mushrooms (annual average during 1966-67 to 1970-71) in canned form is also imported into the country.[2] The canned mushroom which is imported is *Agaricus*. As *Agaricus* is already available, canning in appreciable quantities should be made possible within the country itself to stop imports. A balance sheet of production, import and export is presented below :

	Fresh weight (tonnes)
wild form in terms of fresh weight	360
cultivated	131
imported (equivalent of 6 tonnes of canned quantity)	5
total availability	496
export	288
balance for domestic consumption	208

1 1973. Position Paper on Development of Exotic Types of Mushroom. New Delhi, Crops Division, Department of Agriculture, Ministry of Agriculture, Government of India.

2 Monthly Statistics of the Foreign Trade of India, Vol. II, of March 1967, 1968, 1969, 1970, 1971. Calcutta. Directorate General of Commercial Intelligence & Statistics.

It seems that the internal consumption of mushrooms in India could be placed at about 200 tonnes.

23.6.3 Matters pertaining to organised production of mushrooms have received better attention in Jammu & Kashmir and Himachal Pradesh. In Jammu & Kashmir, there is a full-fledged Department of Mushroom Development, while in Himachal Pradesh, the work is looked after by the Department of Agriculture. Efforts for indoor cultivation of mushrooms were first initiated in 1960-61 with the starting of a scheme of mushroom research at the Agricultural College at Solan (Himachal Pradesh) in cooperation with the ICAR. There is now a modern Mushroom Research Institute and Spawn Laboratory at Solan which also serves as the main centre for the supply of spawn and for training in mushroom growing for the whole country. Mushroom research and development work is also done by the Industrial Development Mission of the Organisation for Industrial, Spiritual and Cultural Advancement, Uttarakhand (Uttar Pradesh) at its centres in Nainital district and in Kashmir Valley. The work relates to two Japanese types, viz., Shiitake and Hiratake. The following other institutions have also been evincing interest in this subject :—

(i) Punjab Agricultural University (Department of Microbiology), Ludhiana.
(ii) Indian Agricultural Research Institute (Division of Mycology and Plant Pathology), New Delhi.
(iii) Hill Fruit Research Station, Chaubattia (Almora).
(iv) Indian Horticultural Research Institute, Bangalore.
(v) Agricultural College and Research Institute, Coimbatore.

The marketing centres for fresh mushrooms are at present in Srinagar, Simla, Delhi, Mussoorie and Bangalore, though supplies are irregular. Preservation of mushroom by canning is gradually developing with increase in production. Scientific drying of mushroom has not developed to any appreciable extent.

23.6.4 On the basis of present trends in taste and status of development, it does not seem probable that mushroom will be widely accepted in the country in the foreseeable future. It will remain a sophisticated article of diet. Moreover, its cultivation cannot be undertaken by all cultivators. In the enthusiasm to overpopularise it, the job should not be entrusted to inexperienced and uninitiated persons or agencies, because hazards of contamination with poisonous types are inherent in various stages of production. Its cultivation has to be kept confined to such persons who have the requisite knowledge of mycology and have been competently trained in the art of cultivation. It should serve as a good avenue for agricultural graduates. Mushroom houses should be started near such cities where it is possible to provide also the dehydrating and canning facilities so that full lifting up of the produce

can be ensured without loss due to spoilage. Dehydrated and canned material has also the advantage of better shelf-life and convenience in transport and export. The prospects of mushrooms in processed forms can be judged from the example of Taiwan. Mushroom canning scarcely existed there before 1960. But that country has developed this industry to such an extent that it earned through exports $ 30 to 50 million between 1967 and 1971.[1] It is learnt that the Republic of Korea has also made rapid strides in mushroom export. Although India is even now exporting its major share of mushroom production, yet the facilities of dehydration and canning can give it a further fillip.

23.6.5 It may be mentioned that the cultivation of *Agaricus* is usually a costly proposition. Therefore, cheaper types like paddy straw mushroom need to be popularised. Other promising forms have also to be experimented upon. Proper spawn production laboratories will require to be established fully under governmental control to avoid chances of contamination and ensure quality. Some enthusiasts in mushroom growing import spawn from abroad through personal resources. This is a dangerous practice, as they can at any time import virus infected strains, which in time can damage the industry. Such imports have to be banned under the quarantine law unless required by recognised research institutions and then also all the technical rigours will have to be compulsorily applied.

23.6.6 The States desirous of strengthening their collection of wild mushrooms or participate in the artificial cultivation of mushrooms will have to create necessary set ups similar to those in Jammu & Kashmir or Himachal Pradesh. The involvement of State Forest Departments will be necessary for the wild mushroom and that of the Departments of Agriculture/Horticulture for the cultivated ones. The latter Departments will be responsible for the training of collectors in identification etc., even in the case of wild mushrooms. These departments should be responsible for inspecting collections in the case of wild material and production in the case of cultivated material so that hazards from poisonous mushrooms can be avoided. Agricultural universities of the concerned States and Research organisations like the Mushroom Research Institute, Solan (Himachal Pradesh), Hill Fruit Research Station, Chaubattia (Uttar Pradesh), the IARI (Mycology & Plant Pathology Division), New Delhi, the IHRI should be collectively as well as individually responsible for mushroom research. The ecological conditions conducive to abundant production of wild mushrooms need study. Hill Fruit Research Station, Chaubattia could specially undertake research

(i) Barron, Louis (editor) 1971, Worldmark Encyclopedia of the Nations—Asia and Australasia, 4th edition : 329, New York, Worldmark Press Harper & Raw.
(ii) 1973. The Far East and Australasia, 1972 : 4th and 5th editions : 985, 937, London, Europa Publications Limited.

on the production of truffles in order to make it a lucrative proposition throughout the oak belt and when successful methods have been evolved for this purpose. State Governments should undertake extension work to popularise truffles in this belt. The Solan Institute, the IARI and the IHRI should try to provide necessary data and advice to the Agricultural Marketing Adviser, Government of India and the Indian Standards Institute to lay down quality standards for dried mushrooms. Compulsory grading of dried mushrooms should be enforced when such standards are established.

7 FLORICULTURE

23.7.1 As in the case of vegetables, in floriculture also there is intensive cultivation in small plots without any meaningful rotation, mainly concentrated around towns and cities, either by the hereditary vegetable growers themselves (*kachhis*) or the hereditary gardeners (*malis*). Vegetable growers plant 'flowers' along bunds, irrigation channels or introduce a few rows amidst the vegetables. Malis, of course, specialise exclusively in flower growing. Additionally, there are a few pockets where floriculture has got established since ages for the manufacture of attar, the most well known example of which is Kannauj (Uttar Pradesh). Though precise data on area under commercial floriculture are not available, it is estimated that an area of 3,000 ha is under these crops in the country. There is a substantial trade in cut flowers, worth Rs. 9.26 crores annually in the five metropolitan cities of Calcutta, Bombay, Delhi, Madras and Bangalore alone. The overall volume of the trade in the country is anybody's guess, but the above facts give an indication of its importance. The consumption of flowers depends upon the local customs and traditions. In Bombay, Madras and Bangalore, for instance, more than 50 per cent of the flowers are for making *veni* and *gajra* the rest being utilised for garlands and for decorative purposes. In Calcutta, nearly 70 per cent of the flowers are for decorative uses and the rest for worship.

23.7.2 Another facet of floriculture in India is the maintenance of ornamentals, hedges and lawns by the Archaeological Department, public parks and gardens, botanical gardens, governmental or private establishments and dwellings of well-to-do people. These represent a better status of inputs, care and interest. Agri-horticultural Societies have existed in metropolitan cities and are gradually extending to other big towns and cities. Annual flower shows are a regular feature of these societies and amateurs derive a lot of enthusiasm

from them. Besides the usual garden plants, cacti and orchids are the other fancies of amateurs. The benefit of researches and modern techniques has been mostly confined to this aspect of floriculture.

23.7.3 In order to cater to the needs of *kacchis* and *malis*, many seedsmen have been in existence as in the case of vegetables. Their main aim has been to keep up the supply of seed to the needy; quality having rarely received any attention from them. For the temperate plants of the hills or those introduced from Europe etc., special centres in the hills have been multiplying their seeds and the seed merchants, who specially took to such plants, had perforce to take steps to ensure that the quality of the imported material did not deteriorate fast. The nucleus for scientific research exist in the horticultural sections of the agricultural colleges or institutions. The ICAR had set up a sub-committee for considering the pattern for research to be adopted in floriculture. The committee expressed the view that a distinction had to be made between ornamental flowers and plants which were imported from other countries every year, and those which were indigenous to India or had undergone long acclimatization under Indian conditions. It was recognised that while in the former, no immediate research was necessary, the main problem in them being proper maintenance and multiplication of imported stocks, in the latter group, there was need for undertaking organised research with a view to improving them to the maximum extent possible. In order to avoid frequent indenting of the seeds and bulbs of the first group of plants, the ICAR sanctioned a Coordinated Scheme for the maintenance and propagation of seeds and bulbs of imported ornamental plants between 1960 and 1965, which worked at Simla, Mussoorie and Ootacamund. In regard to the improvement of the plants of the second group, the subcommittee was of the view that only a few important ornaments, such as, jasmines, roses, orchils, lilies, cannas, crossandra, tuberose, bougainvillea, hibiscus, cacti and succulents should be given priority.

23.7.4 To ensure maximum and quick improvement of ornamentals by selection, hybridization and for formulating agronomic requirements, the ICAR sanctioned another Coordinated Scheme on Floriculture during the same period (1960-65) to function at 9 selected centres, viz., IARI, Saharanpur, Darjeeling, Shillong, Poona, Hyderabad, Bangalore, Coimbatore and Ootacamund. In addition to these schemes, the ICAR sanctioned the following studies:

(i) Cytogenectical and physiological studies in relation to floriculture, at the IARI, New Delhi from 1957 to 1962.

(ii) Investigation into ideal storage conditions for seeds of ornamental plants at Coimbatore and Ootacamund centres, for a period of three years, i.e. 1963 to 1966.

(iii) Research on jasmine, crossandra, and chrysanthemum at Coimbatore from 1962 to 1967.

Research institutes like the National Botanic Gardens, Lucknow, the Indian Botanic Garden, Calcutta and the various agri-horticultural societies have also been evincing interest in research and new introductions.

23.7.5 The main hubs of research activities as a part of the Coordinated Project on Floriculture since the Fourth Plan have been the IARI and its substation at Katrain (Himachal Pradesh), the IHRI and the Botanical Survey of India, Calcutta and Shillong. There are at present 36 centres in all including *thirteen* agricultural universities and some research centres, botanical gardens, parks and gardens of the State Departments of Agriculture/Horticulture (Appendix 23.5). The headquarters of the Project Coordinator's Cell is at Calcutta. Technical programme for these centres provides for all round improvement including collection, maintenance and evaluation of germ plasm, breeding improved varieties, propagation and selection of suitable rootstocks, suitable agrotechniques including nutritional and water requirements and post harvest treatments to prolong storage life in transit and packing for internal markets and for export. The modern trend of utilising chemicals for various purposes has also engaged attention in the country, e.g., for improving seed setting, for root stimulation in cuttings and for producing dwarfs or attractive pot plants. The National Botanic Gardens, Lucknow has been experimenting on tissue culture and a technique for multiplication of orchids from meristems in vitro has also been standardised.

23.7.6 There is a convincing evidence that a good research base is coming up gradually for ornamental plants. In our opinion, the need of the hour is to explore various avenues by which floriculture could be expanded and made more lucrative. One such avenue is provided by the export potentialities of cut flowers and bulbs. Important importing countries are Federal Republic of Germany, England and Sweden for flowers and bulbs and Sweden, England, Switzerland, France, Netherlands and Italy for live plants. America and Canada import flower bulbs, cut flowers and live plants worth 16.5 million dollars mainly from the European Market. In 1958, the USA imported ornamentals amounting to 14 million dollars including $ 147,000 exclusively of cut flowers. These cold countries experience a serious deficit of flowers and ornamental plants in the snow bound months. They do try to grow flowers during their winters in hot houses, yet because of the very expensive nature of this way of growing, they have to resort to imports from countries with a milder winter. From within Europe itself, Netherlands is the

most important exporter but it has to grow material in hot houses. Next to Holland, Italy and France have the advantage of warmer mediterranean climate. For the same reason, Israel also competes in this trade. In Asia, Thailand and Malaysia are the important exporters of cut flowers, particularly orchids and gerbera. India because of its large area and varied agro-climatic conditions has good prospects of increasing its exports in cut flowers, bulbs and ornamental plants. In this connection, the following suggestions are pertinent :

(i) In future when air transport becomes more common, lifting of cut flowers from India at competitive rates should not pose a problem. It would not be surprising if the landing costs work out to be cheaper than the cost of production under glasshouse conditions. What is needed is to develop special floriculture blocks in the vicinity of aerodromes within the country. As these blocks will have to be organised from a scratch, this work could be entrusted to agricultural graduates to start with. It would be preferable to start specialised extensive farms covering a couple of thousand hectares so that the advantage could be given to a group of entrepreneurs at a centre rather than to individuals. Himalayan plants like orchids, azaleas and rhododendrons could be specially considered in this programme.

(ii) Bulbs in dormant condition offer an excellent scope, because these can be easily exported by sea at a lower cost in comparison with cut flowers which have to be sent invariably by air. Care should be taken to export those bulbs only which are native to tropical and sub-tropical areas and are not commonly grown in the open in the Netherlands. It is to be specially noted that India does not compete during summer with the organised Dutch bulb trade of tulips, iris, gladiolus, etc., for which that country is world famous. The type of bulbs India can supply advantageously are those of amaryllis, eucharis, crinum, tuberose, gerbera, lilies, canna etc. Amaryllis bulbs can be successfully grown in the open in Kalimpong (West Bengal), whereas the same have to be grown in most of the advanced countries under heated glass houses. Dutch growers are exporting these bulbs at the rate of Rs. 10 to Rs. 35 per bulb to the USA, whereas India can grow and export the same material at a much cheaper price ranging from Rs. 5 to Rs. 15 each. Kalimpong is

already in the export trade and earns about Rs. 4 lakhs annually. When a small town like Kalimpong with just half a dozen nurseries can achieve this, the implications of this trade, when expanded, can very well be imagined.

(iii) Dry flowers have a very good export market in Europe, the USA and many other countries including Japan. Australia is far advanced in this field and is making substantial supplies to Japan. A visit to the National Botanic Gardens, Lucknow, revealed that they have succeeded in developing methods for preserving the natural beauty of cut flowers in original colours. This centre could be made the pioneer in this field in association with a few more sub-centres situated suitably in different parts of the country and all encouragement should come forth from the Central and State Governments to see that this activity becomes a flourishing proposition. The involvement of agricultural graduates will be welcome in this direction.

(iv) Orchids are more suitable for export than the cut flowers because of better price, lighter weight, easy packing and longer life. Because of the spectacular display of colour, unusual shape and long life of the flowers, orchids are grown throughout the world and flowers and plants are sold at a very high price. About 33,000 hybrids have already been developed in the world. Large scale propagation of outstanding hybrids of several orchids is being done by meristem culture in other countries, but no such attempt on any major scale has been made in India. Evolving new types and multiplying the same under controlled conditions for trade purposes has to be encouraged.

So far in India only naturally occurring orchids have been exploited. The eastern Himalayan region, which is the home of a large number of orchid species, has been ruthlessly denuded because of indiscriminate collection, and often the sale of the whole plants at nominal prices. It is of interest to note that a mature plant of *paphiopedilum insigne,* found abundantly in this country, is sold at a price lower than that of an individual flower of this species in foreign market. The ICAR, realising this situation, has sanctioned an orchid sanctuary project near Kalimpong. This is a step in the right direction and needs to be extended to other natural habitats of various orchids, specially in the western Ghats. Side by side the Govts. of the States concerned have to take measures to block wild orchid collections in a haphazard manner and organise the same on regular scientific basis with due arrangements for regeneration.

Beautification of Urban and Rural Areas

23.7.7 With rapid industrialisation, the repositories of nature with varied gifts, viz., the forests, fields and waterways are becoming the sites of factories, townships and highways. Before it is too late, steps should be taken for maintaining an equitable balance between vegetation and urbanisation. Opportunity could be taken to introduce in all planning programmes a sense of natural landscape. It seems necessary to constitute a Central Committee for Landscaping to survey the scope for landscape planning all over the country and to initiate activities on this aspect. Villages and small towns should also be included in this programme. A widespread planning all over the country is very essential for the maintenance of honey bee fauna, which has been emphasised in Chapter 27 on Apiculture in the context of increased production through better cross pollination. The State Government should actively collaborate with the proposed Central Committee in preparing and executing master plans for various strata of villages, towns and cities and include in their scope the national highways, canals, railways and riverside wherever possible.

23.7.8 The above mentioned two avenues, viz., (a) export promotion and (b) landscape planning, by themselves offer a substantial scope for expansion of floriculture in the country. The suburban areas where floriculture is already concentrated as an occupation will also continue to grow with increasing demands of the population. Because of all these factors, area under flowers and ornamental plants could ultimately expand to about half a million hectares. The proliferation of this vegetation as a part of landscape planning should be so done that nectar bearing flowers are available throughout the year in every part of the country as far as possible. This is essential for the proliferation of bee fauna. It is obvious that the large scale planning and execution of related projects will have to be done directly by the involvement of the State Governments and it is expected as a natural corollary that the required infrastructures with the necessary research and developmental backing will be created by them. However, for the private growers, big or small, professional or amateur, the supply of inputs like quality seeds, fertilisers, pesticides and tools will have to be arranged. Realising the great impact this facility is likely to make in popularising growing of flowers, some firms have already introduced the sale of seeds, garden tools, fertilisers, insecticides and fungicides in small packets to suit the convenience and pocket of individuals. This is a step in the right direction and needs to be extended on a much larger scale.

23.7.9 Lastly, the national flower of India, i.e., the lotus, also deserves consideration. The lotus belongs to family *Nymphaeacae.*

Three genera of this family have flowers of various sizes and colours. These genera are : *Nelumbium* (lotus proper), *Nymphaea* (water lily) and *Euryale* (taal *makhana* or simply *makhana*). Besides being ornamental, their different vegetative parts and fruits are variously consumed in different parts of the country. The underground stem of *Nelumbium* called *bhasinda* in north India is sold commonly in vegetable markets in summer months. The seeds of *Euryale sp.*, when parched or roasted in hot sand, give the puffed up commercial product which is sold under the name of *makhana*. *Makhana* is a delicacy, it is eaten salted or sweet and is known throughout the country, specially in the north. Much work needs to be done to develop the plants of *Nymphaeacae* for the sake of flowers. Their exploitation as vegetable or *makhana* is at present disorganised and is mostly in the hands of individuals. The ICAR could consider how best to develop the ornamental as well as edible aspects of this family. The exact extent of cultivation of lotus and allied species in different States is not known and, therefore, a survey is necessary. Such a survey will enable the State Governments to organise production in a systematic manner and eventually lead to formulation of future plants for improvement. This work can be entrusted to the State Departments of Agriculture/Horticulture. The Departments of Fisheries and Revenue may be able to render valuable help because they may have a better census of ponds and lakes.

8 AROMATIC AND MEDICINAL PLANTS

23.8.1 There are 1,300 species of essential oil bearing plants, but the commonly known ones are sandal, lemon and ginger-grass palmarosa, vetiver (*khus*), mentha (mint), patchouly, pandanus (keora), geranium, rose, celery, clove, jasmine, cinnamon, caraway, eucalyptus, lavender, ocimum, anise, artemisia, etc. The exports of essential oils was of the order of Rs. 6.1 crores in 1973-74. Sandal is the main contributing plant, lemon-grass being the next in importance. Others are palmarosa, eucalyptus and *keora*. The dividing line between the medicinal and aromatic plants is rather thin. Whilst there may be some which can be distinctly identified as being of pure medicinal value or the others being purely of aromatic value, there are a large number of species which have both the characteristics. The organisational problems pertaining to the exploitation of these plants can, therefore, be dealt with under the group medicinal plants. Many of the aromatics are used in the manufacture of *attar*. *Attar* is exclusively distilled using sandal wood oil as base. The plants utilised

for *attar* are either collected wild like *khus* and *keora* or cultivated like rose and jasmine. There exists ample scope for the cultivated *attar* plants or trees like *maulsri* (i.e., *bakul-Mimosops elengi*) to be grown in the areas which have already been earmarked for floriculture. The essential oil bearing plants including sandal, which are of forest origin are considered in Chapter 43 on Minor Forest Produce.

23.8.2 The use of herbal medicines (*Kashtha aushadhis*) in multifarious ways is still considerable in India. Even in modern medicines, many of the plant products are finding increasing use. During the five years ending 1971-72, India exported annually crude herbal drugs to the extent of Rs. 3.3 crores, out of which *isabgol* (psyllium) accounted for nearly 72 per cent and senna for another 17 per cent. The finished products of plant origin consisting of alkaloids, salts and their derivatives accounted for another Rs. 1.1 crores worth of exports and in this category, the two important items were : quinine sulphate derived from cinchona (75 per cent) and nux vomica (14 per cent). But even on these important medicinal plants, work has been going on in a haphazard manner. It was only in 1959 that some rational approach was introduced by setting up the Central Indian Medicinal Plants Organisation, Lucknow (CIMPO) by the Council of Scientific & Industrial Research (CSIR). Aromatic plants were also brought within the fold of this organisation. The scope and functions of CIMPO include introduction of new exotic species, cultivation of medicinal and aromatic plants by the organisation itself or through others and undertaking or encouraging the required research work.

23.8.3 CIMPO has established two Drug Research Laboratories, one in Srinagar and the other in Jammu. These are equipped to undertake manufacture of medicinal preparations on a commercial scale. These units obtain supplies of drugs from the farms maintained for the purpose. The Srinagar laboratory has five farms covering a total area of 440 ha in Kashmir Valley, where pyrethrum, belladonna and peppermint are the main crops. Likewise, the Jammu Unit has two farms with a total area of 515 ha. which grow Japanese mint, ergot, (or rye) *Ammi majus* on commercial scale. CIMPO has also established two zonal centres, one at Haldwani and the other at Bangalore. These zonal centres have also established research, development and demonstration farms. CIMPO has also established three Regional Research Laboratories at Jammu, Jorhat and Bhubaneshwar for work on selected medicinal crops. The Jammu Laboratory also works on botanico-pharmacological survey of wild plants in the regions for identifying new species for industrial utilisation. CIMPO is at present producing annually mentha oil (about 200 tonnes valued at Rs. 2 crores), citronella oil (about 250 tonnes valued at Rs. 2 crores),

ergot (12 tonnes valued at Rs. 7.8 lakhs), diosgenin (8 tonnes valued at Rs. 40 lakhs) and other items like anthotoxin, hyoscyamine, pyrethrum, cedar wood oil, peppermint oil, belladonna, geranium oil, palmarosa oil, *devana* oil etc., which were not produced earlier in the country in commercial quantities. The efforts of this organisation have so far been directed towards development of items which were being imported, as these were considered to be of first priority.

23.8.4 A number of other organisations in the country have also been working in the field of medicinal plants for a number of years. These are mentioned below :—

(i) National Botanic Gardens, Lucknow (under CSIR) : It has done work on *Rauvolfia, Atropa, Artemesia, Podophyllum, Ammi, Dioscorea, Duboisia* and *Valeriana*. It maintains an experimental farm on *Usar* land where studies are conducted on salt tolerance of some of the medicinal plants under commercial cultivation.

(ii) Central Drug Research Institute, Lucknow (under CSIR) : This institute is mainly concerned with conducting pharmacological and clinical trials of various new plant derivatives and identifying new drugs and drug products for their possible utilisation in pharmaceutical industries. It also conducts phyto chemical studies on the composition of these potential plants and plant products.

(iii) ICAR : The ICAR has reorganised research work on these plants under an All-India Coordinated Improvement Project on Medicinal and Aromatic Plants. There are six research centres namely, at New Delhi under the IARI at Bangalore under the IHRI, at Solan under the Himachal Pradesh Agricultural University, at Pilwai (Mehsana) under Gujarat Agricultural University, at Kodaikanal under Tamil Nadu Agricultural University and at Indore under the Jawaharlal Nehru Krishi Vishwavidyalaya. The Coordination Unit is located at New Delhi. The Coordinated Project covers works on improvement in yield and agro-technology on belladonna, digitalis, senna, *isabgol, mulhati,* pyrethrum and rauvolfia. The ICAR is also financing a number of *ad hoc* research schemes for specific crop improvement programmes on different medicinal plants in different universities and institutes. Some of the important crops are poppy, Indian squill, senna and rauvolfia. There is also a coordinated research programme (under the auspices of ICAR, CSIR and Ford Foundation) on *Dioscorea* operating at the IARI, Indian

Horticultural Research Institute, National Botanic Gardens, Lucknow, and the Regional Research Laboratory, Jammu.

(iv) Central Council of Research on Indian Medicine and Homoeopathy : The Council has nine regional research stations spread over the country. Along with other aspects, these stations also conduct agricultural studies on different medicinal plants used in Ayurvedic, Unani and Homoeopathic systems of medicine.

(v) Botanical Survey of India, Calcutta : The Botanical Survey of India has its Central Herbarium and Garden at Shibpur, Calcutta. It has regional stations located at Coimbatore, Andamans, Dehra Dun, Poona, Shillong and Allahabad. It has also phyto-chemical laboratory at Calcutta mainly working on studies of wild plants for clinical utilisation.

(vi) Forest Research Institute, Dehra Dun: This Institute is an important centre for (a) distribution of seed and planting material produced at its two nurseries at Chakrata and Dehra Dun and (b) technical guidance for cultivation and/or exploitation of medicinal and aromatic plants of forest origin. The plants which have engaged attention are about the same as mentioned under (i).

(vii) State Departments: The States of Tamil Nadu and West Bengal have separate Departments of Cinchona and other Medicinal Plants with large plantations located in Nilgiris and Darjeeling districts respectively. While cinchona is the principal crop grown and processed by these Departments, a number of other crops like ipecac, geranium, eucalyptus etc. are also commercially grown in plantations. These Departments also undertake studies connected with the introduction of new crops including agronomical studies on their domestication as commercial crops.

23.8.5 When so many institutions are involved, there is bound to be duplication of efforts. Barring specialised efforts of (a) the Forest Research Institute, Dehra Dun with regard to multiplication and distribution of seed material of the plants of forest origin, (b) Tamil Nadu and West Bengal Governments with regard to cinchona plantations and (c) the Central Council of Research on Indian Medicine and Homoeopathy with regard to the organisation of few research stations to meet their local needs by creating immediate access for themselves to some of the plants of direct concern to them, we strongly feel that handling of activities with regard to research on medicinal

and aromatic plants by a number of organisations is not in the best interest of the country, because it will lead to much duplication of work and frittering away of energy and resources. We are of the opinion that research on production aspects relating to all kinds of medicinal and aromatic plants should be brought under the ICAR. The activities with regard to introduction of the new species should also be with the ICAR. Research on processing and utilisation aspects should be the responsibility of the CIMPO. This arrangement will require coordination between the ICAR and CIMPO.

23.8.6 It has been already mentioned that the use of the herbal medicines is popular to a substantial degree throughout the country, especially in the interior. Commonly used home made medicines are derived from the powders, decoctions and concoctions made out of plant parts. However, the fresh or dried medicinal plants, as a source of medicine, do not enjoy the same confidence as in the past. Due to inherent secretive nature of the herbalists and medicinemen, the knowledge of some of the really efficacious vegetable drugs is dying out gradually. Because of this, the time of collection, the parts used, methods of curing and preserving the drugs are not as well known now as in the past. Commercialisation of collection and utilisation of medicinal plants has further complicated the issue. It is essential to know the proper season and time of collection and the part of the plant to be used. The collection is normally done by illiterate persons, who have had no training in the subject. Unscrupulous persons often offer for sale plants which are not genuine. Often, these have already lost their efficacy because of long storage and insect and mould infestations.

23.8.7 For the sake of convenience, the prevalent herbal medicines or *Kashtha aushadhis* can be classified into two categories viz., (a) whose medicinal values and uses are well understood and which can be identified without any difficulty, and (b) whose medicinal values are well known but their correct identification is uncertain at present. In the case of the first category, the collection is haphazard without any regard to the proper season of picking for maximum potency. The plants are also not cured or preserved in a scientific manner. Even when offered for sale, there is no check on their quality. It is, therefore, not uncommon to find material which has crossed its life of effective activity and in some cases it may even be insect, disease and mould affected. There is, thus, a complete lack of standardisation both at production and collection stages as well as during sale. Immediate steps are, therefore, necessary to create an organisation which should in the first instance lay down standard conditions for collection of different plant materials in respect of their efficacy depending on season and time of collection, the parts of the plants which have different

orders of potency and the periods of expiry. The Botanical Survey of India, Calcutta and National Botanic Gardens, Lucknow, in consultation with the Central Council for Research in Indian Medicine and Homoeopathy, should list all such plants and prepare illustrated descriptions in popular regional languages giving the names, the parts of the plants used, medicinal importance and the methods employed for their use in various common ailments. Legislative measures may be taken, if necessary, for the enforcement of the various standards for which licencing of the traders may have to be resorted to.

23.8.8 In regard to the second category of plants, the medicinal value and uses of which are well known but their correct identification is uncertain, the Botanical Survey of India should bring out illustrated publications giving botanical description, vernacular names and uses of medicinal plants of the country. For the plants of both the categories, as described in this and the earlier paragraph, there is need for standardising procedures for the correct identification and for specifying the parts of the plants used and their expiry period. It has to be recognised that about 1,300 Indian plant species have been listed in various publications as having medicinal uses. Of these, the actual therapeutic value of only 100 to 150 has been scientifically established and active principles isolated. Thus, most of the plants still remain uncovered. The CIMPO, being the main user should constitute on appropriate committee for the purpose. Such a committee should comprise the representatives from amongst the following organisations :

(i) Botanical Survey of India, Calcutta.
(ii) Forest Research Institute, Dehradun.
(iii) Central Drug Research Laboratory, Lucknow.
(iv) Indian Council of Medical Research, New Delhi.
(v) National Botanic Gardens, Lucknow.
(vi) Central Council of Research in Indian Medicine and Homoeopathy.
(vii) Indian Council of Agricultural Research, New Delhi.

9 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

23.9.1 The important conclusions and recommendations which emerge are discussed in this section. The targets of area and yield for the various crops as contemplated for 2000 AD are given in Appendix 23.6. The present position has also been indicated therein for the sake of comparison. Important recommendations regarding areas under different crops are given below :

(i) The target of area under fruit crops for 2000 AD should

be set at 4 Mha.

(Paragraph 23.1.2)

(ii) The imposition of land ceilings would necessitate making available data collected through scientifically conducted experiments with regard to the minimum economic size of an orchard and also with regard to the comparative economics of raising a food or commercial crop as against fruit crops in order to help the farmers determine the proportion of area which they would like to put under fruits. It might also be necessary to give special loans for inducing farmers to go in for fruit cultivation.

(Paragraph 23.1.7)

(iii) Seedling mango trees should be protected and the area under them could also be increased. Their felling has to be regulated so that only useless trees are cut and the correct proportion between removal and replenishment is maintained.

(Paragraph 23.1.9)

(iv) Orchards of grafted mango can be favoured in all such areas which are easily commanded by the markets, whereas seedling mangoes could predominate in the interior.

(Paragraph 23.1.10)

(v) Besides many other situations, community lands like those of the panchayats and the areas released from 'shifting cultivation' in the States of Madhya Pradesh, Bihar (south) and the adjoining areas in Orissa could also be considered for mango planting. Road and canal sides also afford possibilities for this purpose. A study is needed to determine the relative feasibility and proportion of planting road and canal sides with mango and other kinds of trees.

(Paragraph 23.1.11)

(vi) Efforts should be made to increase area under banana considerably. The strategy should be to make its cultivation widespread with preference to small scale production.

(Paragraph 23.1.17)

(vii) It is desirable to encourage the cultivation of guava in as many congenial situations as possible. It is a good tree for homesteads. It could be tried on ravines and common lands under panchayats, etc.

(Paragraph 23.1.28)

(viii) For sour varieties of apples, the area of cultivation specially requires to be extended in order to cope up with the demands of south India. Elevations of less than

1,500 m or more than 2,000 m offer scope for apple cultivation, if and when suitable varieties become available.

(Paragraph 23.1.30)

(ix) It is necessary to study the comparative economics of cultivation of grapes as against the other field crops, which are usually grown in Punjab, Haryana and adjoining irrigated area of Rajasthan with a view to encourage grape cultivation in the area.

(Paragraph 23.1.32)

(x) There is good scope for introduction of pineapple in the areas reclaimed from 'shifting cultivation' in the North Eastern region.

(Paragraph 23.1.34)

(xi) Walnut area in the producing States requires at least to be doubled by 2000 AD, the existing area being 6,000 ha.

(Paragraph 23.1.35)

(xii) Besides the need for area increase through new plantations, there is urgent need for replacing the non-descript or disease-ridden trees in many of the fruit crops through interplanting with the better material and then removing the old ones at an appropriate stage. This specially applies to mango and citrus.

(Paragraphs 23.1.10 & 23.1.22)

(xiii) The area under tapioca in the country should be raised to one million hectares by 2000 A.D.

(Paragraph 23.2.14)

(xiv) The agronomic and economic aspects of inter-cropping in bananas should be worked out in detail. Studies should be conducted on the economics of underplanting banana in coconut groves.

[Paragraph 23.1.18—(iii)]

(xv) Production of vegetables needs to be undertaken in : (a) belts around towns and cities over 2.8 Mha, (b) hills over 0.2 Mha, (c) along tanks, lakes, rivers and canals over 0.8 Mha and (d) kitchen gardens in the interior villages and towns and cities over 0.2 Mha. Kitchen gardens in cities and towns could be developed simultaneously with the necessary promotional activities pertaining to vegetable production.

(Paragraphs 23.4.5, 23.4.8 and 23.4.9)

23.9.2 Recommendations regarding fruit crops pertaining to aspects other than area are given on the next Page.

Mango

(i) Seedling mango should receive due attention in future research and development efforts.

(Paragraph 23.1.9)

(ii) It will be necessary to train a large number of *malis* in the art of budding, grafting and top-working so that they can operate an effective custom service. A vigorous extension programme will also be necessary to educate people to replace their inferior trees and groves.

(Paragraph 23.1.10)

(iii) Hybridization efforts illustrated by the evolution of *mallika* for incorporating the characteristic of annual bearing has to be pursued tenaciously until it becomes possible to release a good number of hybrids with proven record of annual bearing. Similarly, it is also necessary to intensify research efforts to eliminate or control malformation of vegetative and floral shoots.

(Paragraph 23.1.12)

(iv) The commercial varieties, which are under cultivation, at present require to be screened from the view point of genetics and once the cultivars with stable and identical characters relating to plant behaviour, productivity, disease resistance, adaptability, quality and flavour have been identified, these only should be propagated vegetatively on standardised rootstocks. Use of polyembryonic rootstocks would further ensure uniform performance. Breeding efforts have also to go on for evolving better varieties. Some of the desirable characters are dwarfness, resistance to pests and diseases and different maturity periods. Some polyembryonic varieties have shown promise as dwarfing rootstocks and hence could be tried for this purpose.

(Paragraphs 23.1.13 & 23.1.14)

Banana

(v) Improvement in the yield and quality standard of banana crop should be aimed at for the entire area. The problems which need attention in future are spacing of plants for the healthy development, introduction of ratooning, beneficial combinations and techniques of mixed cropping, combating pest and disease problems like those of 'bunchy top', leaf spot (sigatoka) and nematodes, means and methods of reducing water requirement, harvest techniques

and ways of protection of banana bunches from external injuries, insect bites, sunburn etc.

(Paragraphs 23.1.17 & 23.1.18)

(vi) Pending the outcome of spacing trials, a 2m × 2m distance between plants could be advocated as an interim measure. Pending solution of 'bunchy top' disease, in areas where it has assumed very serious proportions (e.g., Kerala), a complete replanting programme is necessary with healthy disease free suckers. In those areas where the disease is not serious, a suitable package of practices for eliminating it could be popularised.

(Paragraph 23.1.19)

Citrus

(vii) It is necessary to find out through experiments compatible stocks for different varieties of citrus for different regions. Future research work should also include evolving of nucellar line plant material; hybridisation work with a view to evolve varieties resistant to root rot and viruses, saline conditions and nematodes.

(Paragraph 23.1.21—(i), (ii) & (iv))

(viii) Studies are also needed to standardise cultural practices for commercial varieties. Suitable schedules of intercrops have also to be developed. The effect of various nutrients in different doses on commercial varieties raised on different rootstocks requires to be studied.

(Paragraph 23.1.21—(v) and (vi))

(ix) Biochemical changes, which are produced in citrus plants by viruses and die-back diseases also require to be studied. The study of virus-vector relationship and sterilisation of vector by irradiation techniques will prove helpful. Another useful direction of research would be to induce resistance against severe strains of known viruses by cross-protection with mild strains.

(Paragraph 23.1.21—(vii) to (x))

(x) The programme of certification, inspection and registration of virus-free mother trees requires to be rigidly enforced. For this purpose it is necessary to multiply virus-free material. It is desirable to draw a programme of replantation of citrus orchards with the best possible disease-free material.

(Paragraph 23.1.21—(iii))

Papaya

(xi) Research work in other countries indicates that gynodioecism with complete elimination of males can be introduced in dioceious cultivars. Either this technique could be adopted or other efforts could be made for breeding stable cultivars. The other desirable characters to be introduced are dwarfness; high yield of fruit as well as papain; and uniform shape, size, texture and flavour of fruit. Suitable control measures and breeding efforts are required for combating diseases like 'damping off', collar rot, mosaic, leaf curl and distortion ringspot. Development of frost resistant varieties is also necessary.

(Paragraphs 23.1.24 and 23.1.25)

Guava

(xii) It is necessary to study which of the guava seasons in a year is better in a particular region with regard to yield and quality. Resistance to wilt disease is required to be introduced in new varieties. It is necessary that unless resistance is proved pathogenetically, no cultivar should be taken as resistant even if it might have been growing unaffected for many years.

(Paragraph 23.1.28)

Apple

(xiii) It is necessary to broaden the genetic base of sweet varieties of apple and in this connection the possibility of utilising wild germ plasm has to be explored.

(Paragraph 23.1.29)

(xiv) Varieties of apples are required to be evolved for elevations lower than 1,500 metres and more than 2,000 metres. The economics of successful apple cultivation at greater heights will also have to be worked out besides the breeding of suitable varieties.

(Paragraph 23.1.30)

(xv) The relative economics of the new method of cultivation of dwarf apples comprising dense planting with specialised training techniques for branches as against the established methods requires to be tried experimentally.

(Paragraph 23.1.31)

Pineapple

(xvi) Pineapple research has to be done on a regional basis. Suitable agronomic and plant protection schedules for different areas are required to be developed and recommended. Methods for activating slip production by using vegetative bud dormancy breakers and reducing the unproductive off-type population require to be worked out. It is desirable to breed a number of good varieties for table purposes as well as for canning.

(Paragraph 23.1.34)

Walnut

(xvii) Walnut needs special attention because it has good potentiality of earning foreign exchange. The problems, which need attention, are production techniques and care of plantations in general and making available walnut grafts for replacing the seedling trees.

(Paragraphs 23.1.8 and 23.1.35)

All Fruits

(xviii) In order to expand the export trade in fruits, it is necessary to evolve a standard procedure for the Indian embassies for enabling them to maintain a constant survey of the changing tastes and requirements abroad so that production programmes within the country could periodically be given the required orientation.

(Paragraph 23.1.3)

(xix) It is desirable that ICAR undertakes research work on the maintenance of ecological balance in the context of minimising damage to fruit crops through animals and birds.

(Paragraph 23.1.5)

(xx) The States should strengthen their horticultural setup in order to be effective enough to undertake the expansion programmes relating to fruits and vegetables etc.

(Paragraph 23.1.6)

(xxi) Clonal selections to choose the best cultivars have to be made in all possible fruit crops in order to ensure a consistent standard of yield and quality.

(Paragraph 23.1.37—(i))

(xxii) More attention is required to be given to tillage aspects of orchards. There should also be provision for irrigation and

adoption of plant protection measures. In short, better agronomic practices have to be developed for different fruit crops and also popularised. Foliar Analysis Laboratories are required to be established in the agricultural universities for estimating nutritional requirements of fruit trees and an associated advisory service is also required to be organised in order to help the growers in this regard.

(Paragraph 23.1.37—(ii))

(xxiii) Research is also necessary to determine :

(a) which crops could be grown under rainfed conditions and in which parts,

(b) which crops would require the full irrigation support, and

(c) which crops would have to depend partly on rainfall and partly on irrigation and in their case to define the periods of dependence on rainfall and on irrigation.

(Paragraph 23.1.37—(iii))

(xxiv) The problem of residual toxicity will also need attention when the use of plant protection chemicals becomes popular in orchards and groves.

(Paragraph 23.1.37—(iv))

(xxv) Improving production through top-working should be extended to as many fruits as practicable. The technique of top-working should be standardised for different crops for large scale adoption.

(Paragraph 23.1.37—(v))

(xxvi) Model orchards are required to be established in every district in order to determine the economics of fruit production. These orchards could also be used as centres of practical demonstration in better methods of cultivation. Research work should be intensified in agricultural universities. Establishment of progeny orchards and supply of genetically uniform nursery stock is of utmost importance on the development side.

(Paragraph 23.1.37—(vi) and (vii))

(xxvii) Two institutes of temperate fruit crops are required to be established, one in the north-western Himalayan belt and the other in the north-eastern hills. Researches pertaining to temperate fruit crops should be the responsibility of these two institutes.

(Paragraph 23.1.38)

(xxviii) The crops which are of local importance from production point of view, should be dealt with by the concerned State

Governments and agricultural universities.

(Paragraphs 23.1.38 and 23.1.39)

23.9.3 Recommendations applicable to many crops in common are given below :

Vegetable Crops

(i) It is necessary that arrangements are made to collect data simultaneously on area and production of vegetable crops, onions, garlic, ginger and coriander in all the States through sample surveys on a periodic basis.

(Paragraphs 23.3.3, 23.4.1, 23.5.2 and 23.5.11)

(ii) The varieties requirements and seasons of various minor crops like onion, garlic, vegetables, ginger, turmeric and chillies vary from place to place. Hence, the research and development work on these crops should be the responsibility of the State Governments. Besides individual States looking after their own problems, continguous States can set up suitable inter-State machinery for mutual benefit.

(Paragraphs 23.3.6, 23.3.9, 23.4.11, 23.5.5, 23.5.7 and 23.5.9)

(iii) Diseases take a heavy toll of the crop in the case of chillies and coriander. Therefore, breeding for disease resistance and developing suitable agronomic and plant protection schedules for combating the menace needs to be given special place in research programmes.

(Paragraphs 23.5.9 and 23.5.11)

(iv) In order that seed, fertilisers and plant protection chemicals become available within the financial capacity of small growers, the sale of such inputs in mini-kits should be popularised in the case of vegetables and floriculture.

(Paragraphs 23.4.9 and 23.7.8)

23.9.4 Recommendations regarding tuber crops, bulb crops, vegetables, etc. are summarised below :—

Potato

(i) The method of crop cutting surveys for estimation of yield of patato should be extended to all important producing States.

(Paragraph 23.2.6)

(ii) The programme for increased potato production must be accompanied by effective marketing system whereby it becomes possible to distribute the produce to different consuming centres throughout the country in order to avoid

gluts in the producing areas. It is also necessary to have adequate cold storage facilities for accommodating surpluses which might still remain.

(Paragraph 23.2.11)

(iii) Disease-pest forecasting, surveillance and plant protection measures are specially required to be developed in the case of potato crop. The problem of residual toxicity of pesticides has also to be solved alongside. The use of polyhaploidy and tissue and organoculture techniques should be increasingly made in developing new varieties.

(Paragraph 23.2.11)

(iv) In the case of sweet potato and tapioca, the Central Tuber Crops Research Institute at Trivandrum should devote attention to basic work including that on breeding. In subsequent stages of breeding work like selection and multiplication, this Institute should take full help from the agricultural universities and the farms of different States. Researches of local importance should all be done in the various States, where the crops are actually grown.

(Paragraphs 23.2.13 and 23.2.18)

(v) There should be a clear-cut programme for developing separate varieties and techniques for culinary and industrial purposes in the case of tapioca. Some of the characters which have necessarily to be incorporated in the culinary varieties are : stalked tubers, medium in size and with good drying-ratio. Small size plants, early maturity and mosaic resistance are some other characters which will be equally good for both the purposes. There is need to lay special emphasis on improving the keeping quality of tapioca tubers through breeding.

(Paragraph 23.2.17)

Onion

(vi) Arrangement should be made whereby uptodate statistics on area and production of onion become available through sample surveys at least once in every five years.

(Paragraph 23.3.3)

(vii) The existing varieties need to be screened for isolating genetic bases. High yielding, disease-pest resistant varieties suitable for different kinds of uses have to be developed together with proper agronomic and plant protection schedules. Botanical studies will have to be undertaken for finding out optimum conditions of flowering, pollination

and seed-setting.

(Paragraphs 23.3.2, 23.3.5 and 23.3.9)

(viii) It is desirable that the home science colleges in general and such colleges or divisions of the agricultural universities undertake research work in order to develop various kinds of palatable recipes from the tuber crops. The I.C.A.R. should provide guidelines and coordinate research work in this regard. The Departments of Agriculture in the Centre and the States could undertake a coordinated programme of publicity through press, audiovisual means and public contact for popularising the use of tuber crops as a part of cereal substitution. Practical demonstrations of taste and preparation of recipes could prove helpful in this regard.

(Paragraph 23.2.20)

(ix) An exhaustive cataloguing could be made of such wild plants, the various parts of which are consumed in the countryside as vegetables. The growth of most useful ones can then be encouraged. This work could be done in co-operation with the Forest Departments.

(Paragraph 23.4.1)

(x) In cities and towns, the liquid and solid products of sewerage should be harnessed and their use popularised to maximum possible extent.

(Paragraph 23.4.6)

(xi) Organising the vegetable holdings in a collective manner for making possible large scale mechanised tillage as well as plant protection operations should be the responsibility of the Department of Agriculture/Horticulture. The Government has to assume responsibility for establishing custom services for various kinds of operations either through co-operatives or governmental organisations. Ensuring to individuals the facility of irrigation should also be the responsibility of the Government. The individual growers should be encouraged to sink wells on joint ownership basis. All possible guidance and assistance in material or finance should also be provided to them.

(Paragraph 23.4.7)

(xii) Crop rotations and companion cropping beneficial from the soil point of view could be introduced in vegetable cultivation and in this respect, short statured beans or fodder legumes like berseem and lucerne could prove very useful.

(Paragraph 23.4.12)

(xiii) Breeding programmes should take into consideration the requirements of processing industry and export and the choice of various countries which have an import potential from India. Hybrid vigour should be increasingly utilised for producing high yielding varieties of quality suited to various purposes and tastes. It will also be good to introduce disease resistance in F_1 hybrids, when possible.

(Paragraphs 23.4.13 and 23.4.14)

(xiv) Leafy vegetables belonging to different species of *Amaranthus, portulaca, Trigonella, Aerva, Alternanthera, basella, Celosia* and various other species should be collected and evaluated for their nutritional and other desirable characters.

(Paragraph 23.4.15)

Ginger

(xv) It is necessary to evolve high yielding fibreless varieties of ginger which have a demand in foreign markets.

(Paragraph 23.5.3)

(xvi) Variety Rio de geneiro is suggested for immediate adoption for internal consumption and processing as an interim measure, but it should not be grown in Kerala.

(Paragraph 23.5.4)

(xvii) Ginger research stations will have to determine the optimum stages of maturity required for the manufacture of various processed articles. Kerala and the North Eastern States of Assam, Meghalaya, Nagaland, Mizoram, Manipur, Tripura, which are important for ginger, should collaborate their research and development programmes. The potential existing in the North Eastern States should be fully exploited both for internal as well as external ginger trade. Other States should also undertake research activities according to their need.

(Paragraph 23.5.5)

Mushrooms

(xviii) The import of canned *Agaricus* should be replaced by indigenous manufacture. At present *Agaricus sp.* is the only one which is cultivated but other types like paddy straw mushroom also require to be encouraged.

(Paragraphs 23.6.2 and 23.6.5)

(xix) The artificial cultivation of mushroom should be organised near such cities where it is possible to provide the dehydrating and canning facilities and this work has to be confined only to such persons who possess the requisite knowhow. They should be preferably agricultural graduates.

(Paragraph 23.6.4)

(xx) In order to provide true to type quality material for production of mushrooms, spawn laboratories have to be started under governmental control. Import of spawns has to be banned, except when required for experimental purposes and that too under rigid quarantine procedure.

(Paragraph 23.6.5)

(xxi) States undertaking the collection programme of wild mushrooms or production programme of cultivated ones will have to create necessary setup in their Departments of Forest and Agriculture/Horticulture. The Departments of Agriculture/Horticulture should be responsible for inspection and extension activities including training of personnel.

(Paragraph 23.6.6)

(xxii) Agricultural universities of the concerned States, the mushroom Research Institute, Solan (Himachal Pradesh), Hill Fruit Research Station, Chaubattia (Uttar Pradesh), the Indian Agricultural Research Institute (Mycology & Plant Pathology Division), New Delhi, the Indian Horticultural Research Institute, Bangalore (Karnataka) should be responsible for mushroom research.

(Paragraph 23.6.6)

(xxiii) All possible measures should be taken to popularise truffles throughout the sub-Himalayan oak belt and the Hill Fruit Research Station, Chaubattia should take up the necessary research work.

(Paragraph 23.6.6)

(xxiv) The Mushroom Research Institute, Solan, the Indian Agricultural Research Institute, New Delhi, and the Indian Horticultural Research Institute, Bangalore, should try to provide necessary data and advice to the Agricultural Marketing Adviser to the Government of India and the Indian Standards Institution to enable them to lay down quality standards for dried mushrooms so that grading is made possible as a compulsory measure in due course.

(Paragraph 23.6.6)

Floriculture

(xxv) An intelligent selective approach is necessary for capturing foreign markets. For example, the best period which can be exploited to India's advantage is winter when temperate and cold countries have the natural handicap of not being in a position to grow plants ordinarily. As far as bulbs are concerned, the country should specialise in exporting such tropical material which is not commonly grown there.

(Paragraph 23.7.6)

(xxvi) For promotion of exports of various kinds of cut flowers, it is desirable to develop special floriculture blocks in the neighbourhood of airports and this activity could preferably be entrusted to agricultural graduates.

[Paragraph 23.7.6—(i)]

(xxvii) Dry flowers also offer a very good export market and this technique has, therefore, to be increasingly utilized.

[Paragraph 23.7.6—(iii)]

(xxviii) Production of new and attractive hybrids of orchids under controlled conditions requires attention. In addition, there is need to protect and proliferate the natural orchid flora of the country. It is necessary to create orchid sanctuaries in the natural habitats of these plants and regulate their exploitation.

[Paragraph 23.7.6—(iv)]

(xxix) Landscape planning with the help of attractive flowering and nectar bearing plants on a country wide scale will also go a long way towards increasing the scope of floriculture in the country. A Central Committee for Landscape Planning should be formed by the Central Government to prepare various alternative landscape plans, to fit into the programmes of development of villages, towns and cities. The State Governments should actively collaborate with the Central Committee in the preparation, and execution of the master plans which should also include in their scope the national highways, canals, railways and riversides.

(Paragraph 23.7.7)

(xxx) The flowers of lotus family should engage special attention in research and developmental activities. The ICAR should encourage research on ornamental as well as edible aspects of this flower. A survey also needs to be undertaken in order to determine the scope for cultivation of the

various species of lotus family which have economic value. The concerned State Governments have to evince due interest for organising production in a systematic manner. The Departments which have a part to play are Agriculture/Horticulture, Fisheries and Revenue.

(Paragraph 23.7.9)

Aromatic and Medicinal Plants

(xxxi) Production research on all kinds of medicinal plants should be the responsibility of the ICAR. The ICAR should also be responsible for introduction of exotic plants. Processing and utilization research should be the responsibility of the Central Indian Medicinal Plants Organisation (CIMPO) of the Council of Scientific and Industrial Research. The ICAR and CIMPO should develop a proper coordination machinery.

(Paragraph 23.8.5)

(xxxii) Insofar as *kashtha aushadhis* or herbal medicines which are prevalent throughout the country for home medicines, are concerned, the Botanical Survey of India, Calcutta and National Botanic Gardens, Lucknow in consultation with Central Council for Research in Indian Medicine and Homoeopathy should list all the concerned plants and prepare illustrated descriptions in popular languages giving the names, the part of the plants used, medicinal importance and the methods employed for their use in various common ailments. It is necessary to indicate the best time of picking for maximum potency as also the period of expiry. If necessary, legislative measures should be taken for the enforcement of the various standards and for this purpose, even licensing of traders may have to be resorted to.

(Paragraphs 23.8.7 and 23.8.8)

(xxxiii) The CIMPO should standardise procedures to certify (a) the correct identification of plants, (b) the parts of the plants used and (c) their expiry periods. They may constitute a committee for this purpose with representatives from (a) National Botanic Gardens, Lucknow; (b) Central Council of Research in Indian Medicine and Homoeopathy; (c) Indian Council of Agricultural Research; (d) Botanical Survey of India; (e) Forest Research Institute; (f) Central Drug Research Institute; and (g) Indian Council of Medicinal Research.

(Paragraph 23.8.8)

APPENDIX 23.1

Fruit Crops

(Paragraph 23.1.8)

Statement I—Average Annual Exports of Fruits (1967-68 to 1971-72)[1]

quantity = tonnes
value = lakh rupees

Fruit	Quantity	Value	Major importing countries
banana	6,683.22	32.72	Bahrain, Kuwait, Qatar, Dubai
walnut (in shell) . . .	1,817.74	54.41	UK, Germany (FR), Germany (DR), Czechoslovakia, UAR, Australia, Poland, Yugoslavia, Canada, Japan, USA
walnut kernel . . .	1,732.32	126.56	
mangoes (fresh) . . .	1,276.26	25.24	Bahrain, Kuwait, Malaysia, Muskat, Qatar, UK, Nepal
tamarind (dried) . .	1,075.09	18.86	UK, Iraq, Italy, UAR, Bahrain, Germany (FR), Kuwait, Germany (DR), Syria
tamarind (fresh) . . .	209.96	2.94	Iraq, Ceylon, Italy, Lebanon, Bahrain, Australia, Germany (FR) . . .
citrus	303.51	5.46	Afghanistan, Bahrain, Singapore, Kuwait, Nepal
other fruits (a) . . .	444.04	11.72	
total	13,542.14	277.91	

(a) apple, grape, fig, pear, apricot, sapota, stone fruits, pineapple, pomegranate, berries, plum, peach, almond, pistachionut, dates, sultana and raisins.

1 Monthly Statistics of the Foreign Trade of India, Vol. I, March, of 1968, 1969, 1970, 1971 and 1972, Directorate General of Commercial Intelligence & Statistics, Calcutta.

APPENDIX 23.1 (Contd.)

Fruit Crops

(Paragraph 23.1.8)

Statement II—Average Annual Import of Fruits (1967-68 to 1971-72)[1]

quantity =tonnes
value =lakh rupees

Fruit	Quantity	Value	Major exporting countries
dates dry (soft) . . .	45,532.44	19.86	Iran, Iraq, Muscat, Saudi Arabia, Afghanistan
dates dry (hard) . . .	10,723.67	164.39	Afghanistan, Iran, Iraq, Muscat, Saudi Arabia
grape fresh . . .	16,777.38	266.28	Afghanistan
raisins	6,804.39	295.62	Afghanistan, Iran
sultana & other dry grapes .	1,753.97	39.48	Afghanistan, Iran, Iraq
pomegranates . . .	4,327.31	71.88	Iran, Afghanistan, Nepal
almonds	2,448.85	193.35	Afghanistan, Iran, Singapore, Iraq
oranges	593.76	3.21	Nepal
pistachionut . . .	432.72	46.56	Afghanistan, Iran
apricots	310.57	14.13	Afghanistan, Iran
other fresh fruits. . .	794.73	11.62	Afghanistan, Nepal
other fruits (a) . . .	362.49	13.92	
total	90,862 80	1,140.30	

(a) Mandarin and other citrus fruits, other edible nuts, pear, quince, plums, mangoes, stone fruits, figs (dried) and prunes, other dried fruits.

1 Monthly Statistics of the Foreign Trade of India, Vol. II, March of 1968, 1969, 1970, 1971 and 1972. Directorate General of Commercial Intelligence & Statistics, Calcutta.

APPENDIX 23.1 (Concld.)

Fruit Crops

(Paragraph 23.1.16)

Statement III—Statewise Average Annual Area, Production and Yield of Banana in India (1968-69 to 1970-71)

area = thousand ha
production = thousand tonnes
yield = tonne/ha

State	Area		Production		Yield
	Actual	Per cent	Actual	Per cent	
Kerala	51.3	22.8	388.1	12.2	7.6
Tamil Nadu	45.1	20.0	807.0	25.4	17.9
Maharashtra	36.3	16.1	869.4	27.3	23.9
Assam	18.0	8.0	237.7	7.5	13.2
Karnataka	16.5	7.3	124.3	3.9	7.5
Andhra Pradesh	16.4	7.3	207.1	6.5	12.6
Orissa	13.6	6.0	106.7	3.3	7.8
Gujarat	13.1	5.8	285.0	9.0	21.8
Bihar	7.2	3.2	42.2	1.3	5.9
Madhya Pradesh	2.7	1.2	50.2	1.6	18.6
Tripura	2.1	0.9	18.0	0.6	8.6
Meghalaya	1.9	0.8	24.4	0.8	12.8
Uttar Pradesh	0.6	0.3	9.4	0.3	15.7
Mizoram	0.4	0.2	5.2	0.2	13.0
A & N Islands	0.3	0.1	2.5	0.1	8.3
all-India	225.5*	100.0	3,177.2*	100.0	14.1

* Excludes figures for West Bengal. The estimates of area, production and yield in West Bengal as reported by the Directorate of Marketing and Inspection in its Bulletin number 163 (1967) on the basis of a survey conducted in 1961-62 were 9.3 thousand ha, 146.5 thousand tonnes and 15.7 tonnes/ha respectively.

APPENDIX 23.2

Tuber Crops

(Paragraph 23.2.6)

Statement I—Statewise Average Annual Area, Production and Yield of Potato (1969-70 to 1971-72)

area = thousand ha
production = thousand tonnes
yield = tonnes/ha

State	Area		Production		Yield
	Actual	Per cent of all-India	Actual	Per cent of all-India	
Uttar Pradesh	165.0	33.6	1,471.6	32.5	8.919
Bihar	100.2	20.4	970.5	21.4	9.686
West Bengal	67.8	13.8	825.9	18.2	12.181
Assam	25.5	5.2	111.7	2.5	4.380
Orissa	23.5	4.8	255.5	5.6	10.872
Himachal Pradesh	16.9	3.4	75.8	1.7	4.485
Madhya Pradesh	15.6	3.2	176.5	3.9	11.314
Meghalaya	15.4	3.1	72.6	1.6	4.714
Punjab	13.7	2.8	189.3	4.3	13.817
Maharashtra	12.3	2.5	50.9	1.1	4.138
Tamil Nadu	11.7	2.4	96.9	2.1	8.282
Karnataka	9.0	1.8	39.7	0.9	4.411
Haryana	4.2	0.9	65.1	1.4	15.500
Gujarat	4.0	0.8	97.7	2.2	24.425
Tripura	2.8	0.6	20.3	0.4	7.250
Rajasthan	1.5	0.3	4.6	0.1	3.067
Jammu & Kashmir	1.2	0.2	5.8	0.1	4.833
Andhra Pradesh	0.6	0.1	1.7	Neg.	2.833
Delhi	0.3	0.1	2.0	Neg.	6.667
Mizoram	0.1	Neg.	0.4	Neg.	4.000
all-India	491.3	100.0	4,534.5	100.0	9.230

APPENDIX 23.2 (Concld.)

(Paragraph 23.2.12)

Statement II— Statewise Average Annual Area, Production and Yield of Sweet Potato (1968-69 to 1970-71)

area = thousand ha
production = thousand tonnes
yield = tonnes/ha

State	Area		Production		Yield
	Actual	Per cent of all-India	Actual	Per cent of all-India	
Bihar	76.2	33.6	591.7	32.8	7.765
Uttar Pradesh	56.8	25.0	592.4	32.8	10.429
Orissa	26.6	11.8	155.9	8.6	5.861
Karnataka	12.5	5.6	87.3	4.8	6.984
Madhya Pradesh	10.5	4.6	62.9	3.5	5.990
Assam	7.9	3.5	24.6	1.4	3.114
Maharashtra	6.9	3.0	88.8	4.9	12.869
Kerala	6.3	2.8	31.2	1.7	4.952
Tamil Nadu	6.0	2.6	60.9	3.4	10.150
Andhra Pradesh	5.0	2.2	33.5	1.8	6.700
Meghalaya	2.5	1.1	5.0	0.3	2.000
West Bengal	2.2	1.0	20.5	1.1	9.318
Gujarat	2.1	0.9	14.8	0.8	7.048
Rajasthan	1.7	0.7	3.0	Neg.	1.765
Tripura	1.5	0.7	9.3	0.5	6.200
Haryana	1.2	0.5	19.6	1.1	16.333
Mizoram	0.5	0.2	1.3	Neg.	2.600
Punjab	0.5	0.2	8.7	0.5	17.400
Andaman & Nicobar Islands	Neg.	..	..	..	..
Delhi	Neg.	..	0.5	Neg.	..
all-India	226.9	..	1,811.9	..	7.985

APPENDIX 23.3

(Paragraph 23.3.4)

Statewise Average Area under Onion during (i) 1957-58 to 1961-62[1] (ii) 1968-69 to 1970-71[2]

(thousand hectares)

State	1957-58 to 1961-62		1968-69 to 1970-71	
	Actual	Per cent of all-India	Actual	Per cent of all-India
Maharashtra	21.7	18.5	40.3	24.7
Karnataka	13.7	11.7	18.0	11.0
Andhra Pradesh	15.0	12.8	16.7	10.2
Tamil Nadu	13.2	11.2	17.7	9.6
Rajasthan	3.2	2.7	6.0	3.6
Gujarat	6.4	5.5	7.3	4.5
Uttar Pradesh	3.9	3.3	5.0	3.1
Madhya Pradesh	8.5	7.2	10.0	6.3
Bihar	4.3	3.7	14.0	8.6
West Bengal	8.9	7.6	..	..
Orissa	8.0	6.8	19.3	11.8
Punjab Region	7.3	6.2	6.0	3.6
Assam	2.0	1.7	3.0	1.8
Jammu & Kashmir	0.4	0.3	1.0	0.6
Kerala	0.5	0.4	..	..
Others	0.4	0.3	..	..
Himachal Pradesh	..	..	1.0	0.6
all-India	117.4	100.0	163.3	100.0

1 Directorate of Marketing & Inspection, Ministry of Agriculture and Irrigation, Government of India.

2 Directorate of Economics & Statistics, Ministry of Agriculture and Irrigation, Government of India.

APPENDIX 23.4

Condiments and Spices

(Paragraph 23.5.2)

Statement I—Average Annual Area and Production of Dry Ginger (1969-70 to 1971-72)

area = thousand ha
production = thousand tonnes
yield = tonnes/ha

State	Area		Production		Yield
	Actual	Per cent of all-India	Actual	Per cent of all-India	
Kerala	11.9	44.2	18.3	53.5	1.5
Assam (a)	4.0	14.9	5.2	15.2	1.3
Himachal Pradesh	1.8	6.7	0.7	2.0	0.4
West Bengal	1.6	5.0	2.2	6.4	1.4
Orissa	1.6	5.9	2.0	5.8	1.3
Madhya Pradesh	1.1	4.1	1.0	2.9	0.9
Karnataka	1.0	3.7	1.3	3.8	1.3
Bihar (a)	1.0	3.7	1.0	2.9	1.0
Andhra Pradesh	0.8	3.0	0.5	1.5	0.6
Gujarat	0.7	2.6	0.6	1.8	0.9
Tamil Nadu	0.5	1.9	0.5	1.5	1.0
Maharashtra	0.4	1.5	0.3	0.9	0.7
Tripura	0.3	1.1	0.4	1.2	1.3
Mizoram	0.1	0.4	0.1	0.3	1.0
Rajasthan	0.1	0.4	0.1	0.3	1.0
all-India	26.9	100.0	34.2	100.0	1.3

(a) In the case of Assam and Bihar, since area and production figures are not available for 1969-70 to 1971-72; area pertains to 1968-69 and production to 1970-71 (provisional estimates). Yields are adopted from the report entitled Marketing of Ginger in India (1965) issued by the Directorate of Marketing and Inspection, Government of India and relate to the period 1953-54 to 1962-63.

APPENDIX 23.4 (Contd.)

(Paragraph 23.5.9)

Statement II—Average Annual Area, Production and Yield of Chillies in India (1969-70 to 1971-72)

area = thousand ha
production = thousand tonnes
yield = q/ha

State	Area		Production		Yield
	Actual	Per cent of all-India	Actual	Per cent of all-India	
Andhra Pradesh	197.4	26.9	115.5	25.6	5.9
Maharashtra	149.9	20.4	79.2	17.5	5.3
Karnataka	106.3	14.5	32.4	7.2	3.1
Tamil Nadu	74.0	10.1	106.5	23.6	14.4
Madhya Pradesh	40.2	5.5	11.0	2.4	2.7
Rajasthan	32.8	4.5	19.2	4.2	5.9
Orissa	29.4	4.0	16.7	3.7	5.7
Gujarat	21.0	2.9	13.4	3.0	6.4
Uttar Pradesh	17.8	2.4	5.4	1.2	3.0
Bihar	16.7	2.3	13.1	2.9	7.8
Punjab	14.2	1.9	13.6	3.0	9.6
N.E. Region	11.3	1.6	6.6	1.4	5.8
Haryana	9.1	1.2	7.4	1.7	8.1
West Bengal	8.0	1.1	6.4	1.4	8.0
Kerala	3.2	0.4	2.6	0.6	8.1
Jammu & Kashmir	0.9	0.1	2.1	0.5	23.3
Himachal Pradesh	0.4	0.1	0.1	Neg.	2.5
Delhi	0.4	0.1	0.4	0.1	10.0
Pondicherry	0.1	Neg.	0.1	Neg.	10.0
all-India	733.1	100.0	451.7	100.0	6.2

APPENDIX 23.4 (Concld.)

(Paragraph 23.5.11)

Statement III—Average Annual Area, Production and Yield of Coriander (1969-70 to 1971-72)

area = thousand ha
production = thousand tonnes
yield = q/ha

State	Area		Production		Yield
	Actual	Per cent of all-India	Actual	Per cent of all-India	
Andhra Pradesh	102.3	36.0	16.3	14.8	1.6
Rajasthan	67.0	23.6	41.9	38.1	6.3
Madhya Pradesh	31.6	11.1	11.0	10.0	3.5
Tamil Nadu	28.3	10.0	10.6	9.6	4.2
Maharashtra (a)	21.3	7.5	16.7	15.1	7.8
Karnataka	13.4	4.7	1.3	1.2	1.0
Orissa	8.0	2.8	4.1	3.7	5.1
Bihar	6.5	2.3	3.2	2.9	5.1
Uttar Pradesh	4.2	1.5	3.4	3.1	8.1
Assam (a)	1.3	0.5	1.6	1.5	12.1
All-India	283.9	100.0	110.1	100.0	3.9

(a) In the case of Assam and Maharashtra since data are not available for the latest years, these have been drawn from the report entitled : 'Marketing of Minor Spices in India (1967)' Directorate of Marketing and Inspection, Government of India. The data relates to the period 1961-62 to 1965-66.

APPENDIX 23.5

(Paragraph 23.7.5)

Statewise Break-up of the Centres of the All-India Coordinated Floriculture Improvement Project

State	Number of centres	Plants on which work is being done
Himachal Pradesh . .	2	gladiolus,narcissus, daffodil, pansy, petunia, rose and other shrubs.
Punjab	1	dahlia, chrysanthemum, carnation, antirrhinum, pansy, petunia.
Haryana . . .	1	bougainvillea, rose, antirrhinum, carnation.
Chandigarh . . .	1	rose.
Delhi	2	gladiolus, amaryllis, iris, bougainvillea, rose, other shrubs, narcissus, daffodil, jasmine, dahlia, chrysanthemum, antirrhinum, carnation, petunia, zinnia.
Rajasthan . . .	1	narcissus, daffodil, rose, jasmine, bougainvillea, croton, antirrhinum, carnation, petunia.
Uttar Pradesh . .	6	gladiolus, amaryllis, iris, lilium, narcissus, daffodil, tuberose, rose, croton, bougainvillea, hibiscus, other shrubs, chrysanthemum, dahlia, jasmine, gerbera, antirrhinum, carnation, pansy, petunia, nymphaea, nelumbium.
Madhya Pradesh . .	2	dahlia, tuberose, rose.
Orissa	1	rose, bougainvillea, tuberose, antirrhinum.
West Bengal . . .	5	orchide, amaryllis, tuberose, gerbera, dahlia, chrysanthemum, rose hibiscus, bougainvillea and other shrubs, jasmine, pansy, petunia, zinnia, nymphaea, nelumbium.
Assam	1	orchids.
Meghalaya . . .	1	orchids, lilium, iris, rose, pansy, zinnia.
Gujarat	1	rose, jasmine, bougainvillea.
Maharashtra . . .	2	rose, jasmine, croton and other shrubs, bougainvillea, dahlia, tuberose, chrysanthemum.
Karnataka . . .	3	orchids, gladiolus, amaryllis, narcissus, daffodil, gerbera, tuberose, rose, hibiscus, bougainvillea, croton and other shrubs, jasmine, chrysanthemum, carnation, pansy, petunia, nymphaea, nelumbium.
Andhra Pradesh . .	1	rose, bougainvillea.
Tamil Nadu . . .	4	orchids, gladiolus, amaryllis, lilium, iris, gerbera, tuberose, bougainvillea, jasmine, rose, croton and other shrubs, chrysanthemum, carnation, zinnia.
Kerala	1	orchids, rose, hibiscus, zinnia, nymphaea, nelumbium.

APPENDIX 23.6

(Paragraph 23.9.1)

Area and Yield Targets of Horticultural Crops for 2000 AD

Crops	Area (Mha)		Yield (tonnes/ha)		Reference		Paragraph
	present	targeted	present	targeted	table	appendix	
fruit crops	1.80	4.00	..	..	..	..	23.1.2
potato	0.49	1.50	9	20	..	23.2 Stat. I	23.2.11
sweet potato	0.23	0.50	8	20	..	23.2 Stat. II	23.2.13
tapioca	0.35	1.00	15.5	40	..	..	23.2.14 } 23.2.18 }
onion	0.16	0.16	10	20	..	..	23.3.6
garlic	0.025	0.025	4	10	..	..	23.3.8
vegetables	0.90	4.00	..	20	..	..	23.4.1 } 23.4.2 }
ginger	0.027	0.027	1.3	2.5	..	23.4 Stat. I	23.5.5
turmeric	0.076	0.076	1.9	3.5	23.2	..	23.5.7
chillies	0.73	0.73	0.62	1.24	..	23.4 Stat. II	23.5.9
coriander	0.28	0.28	0.39	0.8	..	23.4 Stat. III	23.5.11
flowers	..	0.50	..	..	..	..	23.7.8
total	5.068	12.798					

24

PLANTATION CROPS

A very large number of plantation crops are grown in the country. The most important crops from the viewpoint of export are tea, cashewnut, coffee, pepper and coconut. The contribution of coconut in exports is for the fibre, but the importance of coconut to the country lies in its fruit which is useful in various ways. Cardamom and rubber also earn an appreciable amount through exports. Cacao and arecanut are some other important plantation crops. There is possibility of taking up the cultivation of oilpalm, clove and nutmeg also in future to some extent. Tea, coffee, pepper and cardamom have been dealt with in our Interim Report on Certain Important Aspects of Selected Export Oriented Agricultural Commodities. The salient features of these crops as described in the Interim Report are summarised to begin with in Section 1. The other plantation crops are considered in subsequent sections.

1 TEA, COFFEE, CARDAMOM AND PEPPER

24.1.1 Though tea, coffee, pepper and cardamom have been considered in our Interim Report on Certain Important Aspects of Selected Export Oriented Agricultural Commodities, a very brief resume of the salient features of these crops is given here for the sake of completeness of this Chapter with respect to all the plantation crops.

Tea

24.1.2 Tea is grown in India in Northern and North-Eastern States of Assam, Tripura, West Bengal, Bihar, Uttar Pradesh, Punjab and Himachal Pradesh and in the States of Kerala, Tamil Nadu and Karnataka in south India. Total area under tea in the country is of the order of 350,000 hectares. West Bengal, Assam and Tripura

account for 77 per cent and the Southern States for about 20 per cent. Production of tea in the country during the triennium ending 1972 was 425 thousand tonnes and exports averaged about 200 thousand tonnes. Demand for 2000 AD for internal use has been indicated at between 500 and 700 thousand tonnes (vide Chapter 10 on Demand Projections, Table 10.7). During recent years exports accounted for around 50 per cent of total production. In view of good export prospects, we recommended in our Interim Report that assessment might be made of export possibilities after taking into consideration the potential demand both in traditional and non-traditional world tea markets. For increasing the production of the crop, we have considered (a) improving the production efficiency of the existing plantations and (b) bringing additional area under this crop. A survey of the present status of yield performance of individual plantations has been recommended so that developmental activities involving rejuvenation, gap filling, replanting with high-yielding clones, soil conservation, pest control, supply of inputs and efficient management could be launched depending upon the requirements of different plantations. We have also recommended rehabilitation of sick units, which can be done either directly by the Governments concerned through legislative action or by the existing managements themselves. The latter could be encouraged to seek collaboration from tea planters' associations and they could be provided with adequate financial assistance too. Insofar as bringing additional area under tea is concerned, it has been recommended that new areas should be found for the purpose in the Eastern States, Jammu & Kashmir and also in the south. Surplus lands lying unutilized in different tea grants could also be utilized. In establishing new plantations, emphasis has to be on the involvement of small land holders as much as possible and on their organisation into viable cooperatives. Considering the recommendation in the Interim Report on the extension of area and the land available for the purpose, the Commission is of the opinion that the area under tea in 2000 AD could be about 0.45 Mha.

Coffee

24.1.3 The area under coffee in the country has varied between 131 and 138 thousand hectares during 1969-70 to 1971-72 and production between 64 and 110 thousand tonnes. Sixty per cent of area and production is contributed by *Coffea arabica* and the rest by *Coffea robusta*. Coffee is grown mainly in the States of Kerala, Tamil Nadu and Karnataka, which together account for about 99

per cent of its area in the country. Karnataka alone accounts for 60 per cent of the area. Remaining one per cent of area is shared by Maharashtra, Madhya Pradesh, Andhra Pradesh, Orissa, West Bengal, Assam and the Andaman and Nicobar Islands. Demand for coffee for internal consumption in the country in 2000 AD has been indicated at between 100 and 160 thousand tonnes (*vide* Chapter 10 on Demand Projections—Table 10.7).

24.1.4 Coffee exports from India amount on an average to only one per cent of the total world imports. Coffee growing and importing countries are of two categories. One category is bound by the International Coffee Agreement (ICA). Exports of coffee to these countries is effected within the framework of this agreement by different countries on a fixed quota basis. The other category is of non-quota countries. According to FAO, the World demand for coffee is expected to grow at constant prices at the rate of 2.5 per cent per annum during 1970-80. FAO projections imply substantially higher requirements of countries, which at present meet their requirements from India partly. While there is ample scope for stepping up exports both to non-quota and quota countries, such as USSR, Poland, Hungary and Romania, there is need for exploring new markets also. Considering these facts, we recommend that a thorough appraisal be made of the export demand which can be met by this country.

24.1.5 Fifty per cent of the plantations are larger than 10 ha each. These are well organised and duly registered. Some of the unregistered plantations could be large in size and, therefore, viable. However, majority of the remaining plantations are less than 2 ha each and these are neither economical nor properly attended to. All the advantages flowing out of the schemes of the Coffee Board are derived by the registered plantations. Measures such as judicious use of fertilizers, supply of sprinkler irrigation sets under hire-purchase schemes and plant protection are efficiently used in these plantations and, therefore, their performance is superior to others. Efforts have to be concentrated for this reason on the improvement of small holdings. Individual holdings should not be allowed to go below 2 ha and should be suitably knit into cooperatives. These should all be properly registered. Formation of farmers' service societies (FSS) should be encouraged in order to take best advantage of input supply, extension service and credit facilities.

24.1.6 Attention has been drawn towards increasing the production of the existing plantations by selective agronomic practices. Formulation of new plantation programmes on a large scale has also been suggested. Additional areas in the coffee growing States have also to be brought under this crop. Consequently, the area under

coffee in 2000 AD can be projected as 0.20 Mha. The benefit of plantations in new areas should preferably go to small holders. Replantation of areas which have passed their prime period of bearing also requires to be stepped up. Gap filling with suitable varieties is desirable in plantations with patchy growth. Coffee plantations have come up in certain areas which are not congenial for this crop. At the same time, areas which are eminently suited to coffee growing have been planted with other crops like pineapple, orange, etc. Arabica and Robusta varieties of coffee grow best at different altitudes but these have been planted at unsuitable altitudes at several places. We have suggested in our interim Report that such anomalies should be rectified. The total irrigation need of this crop also requires to be determined, because adequacy of soil moisture is the single factor which greatly influences the performance of this crop, specially when rainfall fails in a critical phase like blossoming. Irrigation requirements of small coffee holdings have to be specially kept in view. It may become necessary to introduce sprinkler irrigation in such places.

Cardamom

24.1.7 Cardamom occupies about 76,000 ha of area and its production is about 3,000 tonnes. The crop is concentrated in three States, viz., Kerala, Karnataka and Tamil Nadu. Cardamom exports average about 1,800 tonnes (64 per cent of production). The demand for export and internal consumption in 1984-85 has been indicated at 3,700 tonnes and 1,700 tonnes respectively in the Interim Report. Cardamom yield in the country is very low (40 kg to 45 kg per ha) because of the widespread occurrence of mosaic disease popularly called *katte*. There is need for evolving high yielding varieties resistant to this disease and which are also capable of producing denser capsules. Sanitation measures for controlling the disease including roguing and gap filling with healthy seedlings are necessary as interim measures. There is the usual handicap of the small holders, who possess 60 per cent of the cardamom area, in not being able to take up many of the improvement measures. We have, therefore, suggested that adequate incentives in the form of credit and input supplies along with extension support should be provided to them. All these measures can substantially increase the productivity of the existing area. None the less, feasibility of growing this crop in arecanut plantations and evergreen forests has to be examined in order to extend this crop to additional areas. The area in 2000 AD may be around 80,000 ha.

Pepper

24.1.8 Area under and production of pepper in the country are 120,000 ha and 26,000 tonnes (average for triennium ending 1973-74) respectively. Kerala holds the monopoly with more than 95 per cent of the country's area and production. Only 20 per cent of the production is consumed within the country, the rest being exported. In Kerala, the two districts of Cannanore and Kozhikode account for as much as 60 per cent of area. However, the yield in these districts at 1.4 q/ha is very poor, whereas the overall average in the State is of the order of 2 q/ha. This is because the crop suffers heavily from wilt disease. The primary need is to evolve high-yielding disease resistant varieties. A hybrid, viz., Panniyur I; having a potential of yield of about 6-8 q/ha is already available but it is not resistant to wilt. This hybrid has to be popularised as an interim measure together with due control measures against wilt. With the area remaining stationary and assuming an average yield of 5 q/ha the total production would be 60,000 tonnes at the turn of the century. The Directorate of Arecanut and Spices Development have estimated the export requirements in 2000 AD as 48,000 tonnes; the balance of 12,000 tonnes is expected to suffice for internal consumption.

24.1.9 Pepper is a typical crop grown largely on a small scale in homesteads. Eighty per cent of the total area is of this kind. The question of providing adequate extension and credit support has already been touched in our Interim Report. Because of the small input requirements of a kitchen garden type of crop like pepper, a special programme should be launched to make available fertilisers and plant protection chemicals in small packs so that these could be purchased easily by individual growers. It may also be necessary to explore new sites for cultivation in future. It has been suggested in our Interim Report that some areas in Karnataka, Tamil Nadu, Andhra Pradesh and southern hill areas of Maharashtra might have good potential in this regard. Growing of pepper in the plantations of coffee, arecanut and coconut should also be tried.

24.1.10 A recent development pertains to the establishment of an Asian Pepper Community in March 1972 with India, Indonesia and Malaysia as the original signatories for safeguarding their interests as the main producers, to devise joint cooperative measures to achieve and maintain stability of international prices, expand and develop new markets and promote research and developmental work. It is hoped that India will be able to derive advantage from this joint venture in future.

2 RUBBER

24.2.1 The industry distinguishes three kinds of rubber, viz., the natural rubber of plant origin, the synthetic rubber and reclaimed rubber. Synthetic rubber is derived from certain unsaturated hydrocarbons. Reclaimed rubber represents the feedback from worn out rubber goods and, therefore, is nothing newer than the other two kinds. India has never been self-sufficient in this commodity so far. The extent of import of natural and synthetic rubber is indicated below[1] :

TABLE 24.1

Imports of Rubber 1950-51 to 1970-71

(thousand tonnes)

Year	Quantity	Remarks
1950-51 – 1955-56	3 — 5	—
1956-57 – 1959-60	10 — 21	—
1960-61 – 1966-67	18 — 35	In two years the imports were 18 and 19 thousand tonnes and in the other years the range was 30—35 thousand tonnes.
1967-68 – 1970-71	7 — 23	One year 7 thousand tonnes, two years 12-13 thousand tonnes, one year 23 thousand tonnes.

24.2.2 The position with regard to the consumption of synthetic and natural rubber within the country may be seen below in contrast with the world trends :

TABLE 24.2

Consumption of Synthetic Rubber as percentage of total Consumption of Rubber

Years	India	World
1956-1959	8—10	41—48
1960-1964	13—19	52—60
1965-1970	24—27	61—66

1 Statistics quoted here and in subsequent paragraphs are obtained from the *Indian Rubber Statistics*, 12, 1971, the Rubber Board, Kottayam (Kerala).

The use of synthetic rubber in UK, France, Germany (FR), Italy, Netherlands and Japan in 1970 was around 60 per cent; whereas in Brazil, Canada and the USA, it was between 70 and 80 per cent. Considering the trends abroad, it is reasonable to assume that the proportion between natural and synthetic rubber even in India would at least become 50 : 50 by 2000 AD. The Rubber Board has estimated the total demand of rubber coming from all sources to be 1.5 million tonnes in 2000 AD. Accordingly, the requirement of natural rubber in 2000 AD may be taken to be of the order of 750,000 tonnes. Further consideration in this Section will be confined to natural rubber alone.

24.2.3 Natural rubber represents the plant sap in its condensed and processed form. *Ficus elastica, Cryptosteqia grandiflora* and *Hevea brasiliensis* have been tried as sources of rubber at different times in India. *Ficus elastica* abounds in Assam and people there have been acquainted with the properties of its gum-elastic since long and put it to various uses, so much so that the rubber from this source had come to be known as Assam rubber. They used to waterproof their baskets with this rubber and even burn it as candle. It was exploited on a commercial scale to meet the demand of the market in Britain in the first quarter of the nineteenth century. However, the exploitation exceeded replenishment and, therefore, the plant came almost to a point of extinction. Meanwhile *Hevea brasiliensis* attracted attention as a major source of rubber in the world. The Kew Gardens of UK had received a few hundred seeds of *Hevea* in 1873 from Brazil. Some of the seeds from this stock were utilized for trials at the Royal Botanical Garden at Peradeniya in Sri Lanka and the Indian Botanical Garden, Calcutta. Experiments soon proved that this plant could be successfully grown in Kerala. The earliest rubber plantations were started in Periyar and Poonor (Kerala) in 1905. The emphasis on growing the plant was primarily to supply natural rubber to UK rather than to develop the industry in this country. The Government of India took various measures to safeguard the interest of this rubber from time to time. Prices of rubber fell to low levels during the great depression of the thirties. India joined the Rubber Regulation Agreement which was brought into force in 1934 to regulate exports, imports and subsequently new planting and replanting. As a consequence, there was an improvement in prices of rubber. The events of World War II led to increased attention to the growing of *Hevea* in India, because much of the supply going to Britain from Malaya, Indonesia and Indo-China had been cut off. Attention at this stage was given not only to increase the production of *Hevea* but also to examine other plants for tapping latex. *Cryptosteqia grandiflora* was tried in

this context, but it did not prove to be a success. Therefore, *Hevea* continued to hold ground as the sole supplier of natural rubber in the country.

24.2.4 Driven by the exigencies of World War II, the Government of India passed the Indian Rubber Control and Production Order, 1942, constituting the Indian Rubber Production Board with the object of encouraging and ensuring increased production of rubber by all possible means. Later on, the Rubber (Production and Marketing) Act, 1947 was passed to replace the Indian Rubber Control and Production Order of 1942 and a statutory organisation—The Indian Rubber Board—was constituted to look after the interests of rubber producers through such measures as price control and import restrictions. A new Act, the Rubber (Production and Marketing) Amending Act, 1954 was brought in and the Board was reconstituted in 1955. Under the provisions of this Act, all the rubber growers and dealers are required to register their names with the Rubber Board. A licence from the Board is required for growing any kind of rubber or for carrying out new planting or replanting. Similarly, a dealer has to get a licence to deal in raw rubber or to acquire new rubber for the purpose of manufacturing or for sale. In order to help development plans, a cess is collected by the Rubber Board particularly for subsidizing replanting. All research and development activities pertaining to natural rubber in the country are controlled and regulated by this Board. There is also an International Rubber Research and Development Board which coordinates activities of all the rubber growing countries. Another international organisation which takes active part in the discussion and decision-making regarding rubber industry is the Association of Natural Rubber Producing Countries.

24.2.5 The Rubber Board established the Rubber Research Institute of India (RRII) at Kottayam (Kerala) in 1955. Two experiment stations were later on established at Chethackal (Kerala) and Port Blair (Andaman and Nicobar Islands). These stations carry on research work on botanical, agronomical, pathological, entomological, biochemical and other scientific aspects of rubber cultivation and processing. As a result of research efforts, several high yielding clones have been evolved in India. Improvements have also been effected in the budding techniques which resulted in a high percentage of success and consequently in the reduction of pretapping (juvenile) period by one or two years. Recommendations on fertiliser application to rubber trees of different age groups are now available. The nutrients, viz., NPK and Mg, have to be applied in a balanced proportion in order to avoid nutritional disorders. A plant stimulant, Ethrel, has been found to increase the yield significantly. Use of the legume, *Pueraria Phaseo-*

loides, is found to be beneficial as a ground cover. Herbicides have been identified for successful eradication of most weeds occuring in plantations. Abnormal leaf-fall caused by Phytophthora palmivora and powdery mildew caused by *Oidium heveae* are the two main diseases for which suitable control measures have been evolved. However, the control measures are costly and cumbersome and, therefore, there is a great need for breeding varieties endowed with natural resistance.

24.2.6 The developmental activities of the Board are carried out by five regional offices at Trivandrum, Kottayam, Palai, Ernakulam and Kozhikode and a dozen sub-offices situated in Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Tripura and Goa. In order to ensure the supply of suitable planting material, the Board runs its own nurseries and also approves private nurseries. The Board also arranges demonstrations in the improved methods of tapping, latex collection and its processing besides the control of 'tapping panel diseases' (i.e., diseases which develop at the places of incisions) and organises tapping classes. Help is also provided in the import of machinery, equipments, chemicals, etc., required by the growers. There are schemes run for rendering financial assistance, e.g., 'replanting subsidy' and loan for 'new planting and maintenance'. The Board arranges to distribute fertilisers and fungicides at concessional rates. Distribution of planting materials and plant protection equipment is also arranged. The Board renders assistance to rubber marketing cooperatives too.

24.2.7 Rubber plantations in India range in size from less than a hectare to over 1,000 ha each. Plantations upto 20 ha can be classed as 'small holdings' and the larger ones as 'estates'[1]. Information regarding the number of small holdings and estates together with their area and production for the period 1960-61 to 1969-70 is given in Appendix 24.1—Statement I. The following broad conclusions emerge from these data :—

(i) of the total rubber plantations, small holdings preponderate (99 per cent);

(ii) the ratio of area between small holdings and estates was 59 : 41 in 1960-61 and 67 : 33 in 1969-70;

(iii) increase in area has taken place in both the classes but the increase in the number of small holdings has been disproportionately high so that their average area which was 1.33 ha in 1960-61 gradually came down to 1.23 ha by 1969-70;

(iv) the average area per estate which was 97 ha in 1960-61 improved marginally to 102 ha by 1969-70;

1 1974. Unny, R.G., Pattern of growth of rubber plantation Industry, Souvenir Rubber Planters' Conference, India, Kottayam (Kerala). Rubber Board.

(v) the average yield has shown improvement in both the cases. In the case of small holdings, the yield improved from only about a quintal per hectare in 1960-61 to about 3.4 q/ha by 1969-70. For estates, the average was about 3.6 q/ha in 1960-61 and increased to 5.8 q/ha by 1969-70;

(vi) the contribution of small holdings to overall production went up from 27 per cent in 1960-61 to 54 per cent in 1969-70.

24.2.8 Kerala, Tamil Nadu and Karnataka account for bulk of the country's area and production and of these, Kerala alone accounts for about 93-94 per cent. Statewise estimates of area and production for the year 1965-66 to 1969-70 are given in Appendix 24.1—Statement II. Karnataka has the least area (1.9 per cent of the total in 1969-70) and its yield standard is also the poorest (just about 1.5 q/ha in recent years). Tamil Nadu has about 5 per cent of the area and its yield has ranged between 4 and 5 q/ha. Overall yields in Kerala are lower than in Tamil Nadu and varied between 3 and 4 q/ha. The position of tappable plantations has been examined separately in Appendix 24.1—Statement III. Yields are the highest in Tamil Nadu at more than 8 q/ha. The yield obtained from tappable plantations in Kerala ranged between 4 and 6 q/ha and the yield in Karnataka was around 3 q/ha in this period. A combined study of Statements II & III of Appendix 24.1 would reveal that the tappable area in terms of the total rubber area in the three States has been of the following order :—

TABLE 24.3

Percentage of Tappable to Total Rubber Area

Year	Kerala	Tamil Nadu	Karnataka	All-India
1965-66	67	60	78	68
1966-67	67	60	76	66
1967-68	66	59	44	65
1968-69	67	54	44	66
1969-70	69	54	37	67

Reduction in tappable area in recent years in Karnataka and to a lesser extent in Tamil Nadu is indicative of new plantations, which are young and hence not fully tappable. The yields given in Appendix 24.1—Statement II also corroborate this fact.

24.2.9 It has been experimentally shown that the yield level of rubber plantations could be pushed up many times. Cultivar RRII—208 has already recorded yield of 4 tonnes per hectare with a package of improved cultivation practices even in the fourth year of tapping. Considered from this standard, the present yields even from the tappable area are low. One of the important causes, that keeps the existing levels of yield much below the experimentally attainable potential, can be attributed to the plantations which are derived from ordinary, low yielding and unselected planting material. The area under such plantations is about 60 per cent of the total. No doubt, the rubber growers—whether small or big—have benefited from the improvements in cultural practices brought about by the endeavours of experiment stations and by various other kinds of facilities which have been provided by the Rubber Board, but the small growers have not been in a position to utilise the various facilities to the desired extent. This applies specially to 'replanting subsidy' and the 'new planting loan' schemes. A limited survey was conducted in a taluka of Kerala during 1974 to study the response of small growers to the aid schemes of the Rubber Board[1] and a review of the entire rubber plantation industry has also recently been made by the Chairman of the Board[2]. It is felt that the small holdings (particularly below 4 hectares) have awfully lagged behind.

24.2.10 The main reason for the lack of interest of small holders in replantation is the low rate of subsidy offered at present, which does not offset the loss of income during the pretapping period and this means waiting for about seven years for full returns. The current rate of subsidy fixed in 1960 is Rs. 2,471 per hectare. The new planting loan scheme also has not progressed satisfactorily because of inadequate amount of loan, non-availability of suitable land with growers, etc. The Board is trying to remove both these lacunae during the course of the Fifth Plan period. The rate of subsidy has been proposed to be revised upwards and liberalised loan schemes with enhanced rate of loan amounts for both the traditional and non-traditional areas are already under consideration. It is hoped that the handicaps usually faced by small holders in obtaining the various facilities from institutional agencies, can be overcome by organising them into effective cooperatives. There is also need for forming organisations like FSS or cooperative service organisations, supported by the State, for doing custom service for pest and disease control operations which are ordinarily not within the means of small rubber

1 1974. Report of Sample Survey of Response of Small Growers to the aid schemes of the Rubber Board, Kottayam (Kerala). Rubber Board.

2 1974. Souvenir, Rubber Planter's Conference, India, Kottayam (Kerala). Rubber Board.

growers. For the same reason, there is also need for a common service for processing of latex which is required to be processed soon after tapping for getting the best value out of the rubber. In bigger estates, they have the equipment and machinery to make best use of latex for marketing. Small farmers are at a disadvantage because either they have to sell latex to other operators or get only inferior rubber out of it. This disadvantage will disappear with common service societies.

24.2.11 Removal of the above mentioned lacunae will undoubtedly have a far-reaching effect in improving the yields. The receptivity of growers for new techniques is an important factor which can go a long way towards effecting improvements. It is easy to replace the existing plantations, but it is difficult to educate the present growers *en masse* on the right methods of management. It is, therefore, worth considering whether their children can be given agricultural education with a bias towards plantation crops so that these youngmen will take the place of their parents in course of time with a good knowledge on plantation management at their command. With all these measures taken together, it should be possible to upgrade the yield level to 2 tonnes per hectare at least and with this yield rate as the standard for 2000 AD the total production accruing from the present (1969-70) area of about 200,000 hectares will come to around 400,000 tonnes.

24.2.12 It may be recalled that the demand projection for natural rubber for 2000 AD was placed at 750,000 tonnes (vide Paragraph 24.2.2). This will mean that 350,000 tonnes will have to come from an additional area of 175,000 ha assuming the yield to be 2 tonnes/ha. Trial plantations have been made in Assam, Tripura, Goa, Maharashtra and Andhra Pradesh. The performance in Assam and Tripura has been found to be promising. It has been observed that plantations in Tripura are at present entirely free from fungal diseases. Freedom from diseases not only cuts off expenditure on control measures but also leads to higher productivity. Owing to these two reasons, Tripura has a definite edge over the traditional rubber growing region of the south. If Tripura can have this advantage, there is no reason why similar agro-climatically situated pockets in Assam and adjoining States of the North-East should also not possess the same. If disease free conditions could be ensured, large areas can be brought under rubber in this region.

24.2.13 It has been estimated that about 100,000 ha could be put under rubber in Assam and adjoining parts (including Tripura) and the Andaman and Nicobar Islands[1]. The balance of the additional

1 Joseph, K. M., P. M. Menon and R. G. Unny, Strategy for development of rubber Plantations to 2000 AD. (A cyclostyled communication received from the Rubber Board, Kottayam—Kerala).

area, viz., 75,000 ha, will have to be found in the Peninsula itself. Availability of suitable lands in Kerala and Tamil Nadu for any further large scale extension of rubber plantation is limited. South Kanara and adjoining districts in Karnataka do still afford some opportunity for extension. Further north, the rainfall gets more intensified and restricted to a few monsoon months and this imposes a handicap for the rubber plant which requires distribution of rainfall over as many months as possible. However, congenial situations along the Western Ghats in Maharashtra and elevated areas in Andhra Pradesh and Orissa are worth a trial. Attempts should be made to evolve varieties, which are hardier than those adapted to more humid parts. For the extension of rubber plantations in new areas, it is worth examining whether preference could be given to agricultural graduates. Suitable minimum viable units of plantations can be so formed as to give a decent living to a group of about 5-6 graduates, who could form cooperatives to manage the same.

3 CASHEWNUT

24.3.1 Cashewnut is primarily known for its kernel, although the so-called "cashew apple" is edible in fresh form and its juice is utilised in syrups or fermented liquors, and the oil exuding from the hard shell of the nut itself is also variously usable. The nut is rich in protein as well as fat content; its fat has less of saturated fatty acids and, therefore, it is less fattening than the almond—its rival dry fruit. But it is less expensive and therefore more popular than almond. Though originally native to northern parts of South America, about two-thirds of the world production now comes from Africa. The cashewnut plant was introduced in India in the sixteenth century by the portuguese primarily for covering barren hills to check soil erosion. Later on, it became a popular edible nut and gained export importance. The cashew processing industry is said to have been started in South India in the 1920s getting impetus from foreign demand, specially from North America. The peculiarity of India lies in the fact that, although its own production of raw nuts is only about 20 per cent of world's production, its share in the world's total export of cashew kernels has ranged between 75—91 per cent in the period 1965—69.

24.3.2 The country has specialised as by far the most important centre for processing cashewnut. It imports nearly as much of raw nuts from African countries as its own production for processing and exporting the kernel to other countries, the export being of the order of 75 per cent of the total processed quantity (Appendix 24.2—

Statement I). This dependence on other countries cannot be allowed to continue in future years. Appendix 24.2—Statement II shows that Mozambique, Tanzania and Brazil are entering the export market for processed kernels and in an ever increasing manner. Therefore, the country has to plan for full production of the raw cashewnut by itself and compete with the other producers of the processed product. The selling price of cashewnut depends not only on the cost of production of raw nuts, but also on the cost of processing into marketable kernels. The cost of production of the raw nuts can come down only when the yield standards get improved. Processing cost has been high in the past because of manual operations, but now roasting has been already mechanized, shelling is partly mechanized, but grading is yet manual. With the progress of mechanization, the cost is likely to come down in future. Manual operations undoubtedly have an advantage inasmuch as the kernels remain whole without breakage, but constant technological improvements are being made in other countries to incorporate this advantage in mechanized processing too.

24.3.3 Attempts towards improving cashewnut crop had been ineffective until about 1951, when certain special steps were initiated. The ICAR sanctioned three research schemes in the cashewnut producing areas of the then States of Bombay, Madras and Travancore-Cochin for starting research stations. The then Ministry of Food and Agriculture constituted the Spices Enquiry Committee (1953) for examining the production and marketing aspects of spices and cashewnut. As recommended by the Committee, the Government of India provided enough funds for research, development and marketing for the cashewnut growing areas. The ICAR constituted a Central Spices and Cashewnut Committee consisting of government officials, growers and traders for assisting it in its functions. The Committee functioned until September, 1961 when the Indian Central Spices and Cashewnut Committee (ICSCC) came into being as an independent body (a registered society). The Central Plantation Crops Research Institute (CPCRI) was established at Kasaragod (Kerala) in 1970 and was *inter alia* charged with the responsibility of cashewnut research. Cashew research stations belonging to State organisations also exist at Kottarakara and Anakkayam (Kerala), Vridhachalam (Tamil Nadu), Ullal and Vittal (Karnataka), Vengurla (Maharashtra), Bapatla (Andhra Pradesh) and Kothiatoli (Assam). The ICAR initiated the Coordinated Development Project for Spices and Cashewnut in 1970 with a coordinating cell and a Regional Research Centre at Kasaragod. Research Centres at Anakkayam, Vridhachalam, Vengurla and Bapatla are also participating in this project.

24.3.4 The progress of research work on cashewnut and the lines

for future work are discussed below :

(i) One hundred and fifty-three indigenous and exotic selections of promising types have been assembled at the CPCRI. Sixteen types from Vridhachalam and 4 each from Anakkayam, Vengurla and Bapatla are considered superior. The work of assessing their adaptability and yield potential under different agro-climatic conditions, which is essential to be completed before popularising the better selections, has yet to be done in a conclusive manner. Simultaneously, floral biology of cashewnut has also attracted some attention. It is found that only six per cent of the flowers are bisexual and even out of these only 50 per cent are successfully pollinated in nature. Even after fruitset, 15 per cent of fruits drop due to defective fertilization. Although sporadic attempts have been made for hybridization, yet it may be noted that for any mass scale genetic improvement, the handicaps of a very small number of hermaphrodite flowers, low pollination and defective fertilization will have to be removed and this should engage the attention of scientists on a priority basis. Until this has been achieved, the main emphasis will have to continue on selection work and, therefore, release of duly tested high yielding varieties out of the existing stock should be the short-term objective.

(ii) Cashewnut is mainly propagated through seed, but considerable heterogenity exists at present in regard to seed size, germination capacity and growth behaviour of seedlings. Although these defects are attempted to be overcome to some extent through sorting of seed material and regulating the time of storage, yet this is not a lasting solution. Fortunately, vegetative propagation is found to be superior to propagation through seed. Air-layering has been found to be the best vegetative method. Accordingly, the Government of India provided financial assistance to the States of Kerala, Karnataka, Goa, Daman and Diu, Andhra Pradesh and Orissa for the production of air-layers from high yielding trees in the existing plantations. The handicaps that have come to light are (a) the parent trees are located far apart, because of which air-layering operations become difficult and (b) the selection of parent trees is not backed up by established records relating to yield etc. The most important factor which has emerged against air-layering is the poor development of the tap root because of which

the plants do not establish very satisfactorily. An alternative method of improvement is through the technique of *'in situ'* grafting. This has been found successful and a large scale programme in this regard has been sanctioned in the Fifth Plan. Mostly side-grafting is adopted for this technique. The Fifth Five Year Plan period will give an opportunity to test the success of this new method of clonal propagation on a mass scale. If the results are encouraging, the existing plantations could be improved by inter-planting with the new material and gradually cutting away the unproductive trees.

(iii) Important pests causing damage to cashewnut plants are *Helopeltis antonii* (tea mosquito). *Placaederus ferrugineus* (stem borer), *Chilaria heligramma* (shoot-tip and inflorescence caterpillar), *Curicular trifenestrata* (leaf-eating caterpillar) and thrips. Chemical control measures have been evolved for tea mosquito, which is most harmful because it aggravates losses due to blossom-blight and die-back diseases. Control measures have to be evolved for other insect pests and for fungal diseases like mildew.

(iv) It is shown that production of cashewnut can be stepped up more than four times by applying cattle manure in combination with ammonium sulphate and superphosphate. Application of leaf mulch round the cashewnut trees results in higher yield. However, work on agro-techniques such as spacing and intercropping etc. for different areas is yet to be done. It is necessary that packages of practices including plant protection are evolved for different regions and made available to the growers.

24.3.5 The overall implementation of cashew development programmes is the responsibility of the Directorate of Cashew Development under the Ministry of Agriculture and Irrigation, which was created with its headquarters at Ernakulam (Kerala) soon after the abolition of the ICSCC in 1966. It has sponsored with success an area expansion scheme under the State Sector. Besides, the Directorate has also been sponsoring Central schemes like (a) production of cashew airlayers, (b) laying out demonstration plots for improved practices in cashewnut cultivation, (c) adoption of prophylactic plant protection measures, (d) marketing surveys and (e) special schemes for area expansion and package programmes in departmental areas. The drawbacks of the production of cashew airlayers have already been mentioned. The progress under other schemes has not been rapid enough to cover an extent of area which should have made conspicuous addition in production level.

24.3.6 The Directorate of Economics and Statistics publishes data on area and production of cashew. There seems to be some under-estimation of area under cashew in respect of some of the States. The Directorate of Cashew Development built up estimates based on the surveys conducted by the Institute of Agricultural Research Statistics and other information received from State Governments from time to time and supplied the same to this Commission on request. The data so furnished are given in Appendix 24.2—Statement III. Some broad conclusions which emerge are stated below :

(i) About 70 per cent of area and 80 per cent of production is accounted for by the States of Tamil Nadu, Kerala and Karnataka.

(ii) About 25 per cent of area and 17 per cent of production is accounted for by Maharashtra, Andhra Pradesh and Goa.

(iii) The yields in Kerala are around 1 tonne/ha. Andhra Pradesh records yields of about 6 q/ha. Elsewhere, the yields are much lower, the average for the country being about 4 q/ha.

It has been observed from the data for 1971-72 furnished by the CPCRI that private plantations predominate in Kerala accounting for 94 per cent of the total area under the crop. Yield data are not available separately for private and Government plantations. However, yields are likely to be lower in Government plantations which lie mostly in forest areas where exclusive attention to cashew trees could not be given. In other States, particularly Maharashtra and Orissa, the emphasis in planting cashew has been more on the soil conservation aspects rather than on fruit production. These seem to be the probable reasons for low yields in States other than Kerala.

24.3.7 Cashew trees in forests are naturally the responsibility of the State Forest Departments. Plantations in private lands are looked after by the Agriculture/Horticulture Departments insofar as extension, advice and supply of inputs are concerned. Because of the two agencies involved, it has often been proposed in horticultural seminars and conferences that a separate authority be created in each State for the development of cashew crop. Forest Departments have their own responsibilities with regard to the national forests and, therefore, it does not seem to be a workable proposition to create a divided responsibility for managing the forest plantations between the suggested authority and the Forest Departments. We are inclined to believe that what is needed is to prepare common guidelines and coordinate activities pertaining to cashew improvement programmes between the Departments of Agriculture/Horticulture and Forest. The Departments

of Agriculture should try to ensure that the plantations are made with the best possible material and these are taken care of in a scientific manner with the provision of necessary inputs from time to time, whereas the Departments of Forest should ensure that they bestow upon this tree the same attention as is required for any plantation crop under their charge. Scientific steps, which are needed for improvement, will be the same in both the cases. Some important indications in this regard have already been made. In addition, many of the existing trees could be top-worked with advantage in order to give them a new lease for better performance. The cashew tree has the potential of giving an yield of 10 kg of raw nuts per annum both in privately owned and forest plantations. Assuming about 250 trees to a hectare, this would mean an yield of 2.5 tonnes/ha. However, considering the present status of the crop, the target for 2000 AD may be kept at 2.0 tonnes/ha only.

24.3.8 A reference to Appendix 24.2—Statement I would show that the total quantity of raw nuts handled annually by the processing units within the country between 1967-68 and 1969-70 averages to about 360,000 tonnes. By 2000 AD, the quantity could be reasonably expected to approximate 700,000 tonnes and all of it will have to be produced from the country's own plantations in order not to depend on imports. This would mean that the present area of 220,000 ha would have to be increased by another 130,000 ha yielding at the rate of 2 tonnes/ha. Surveys have been conducted in various States and by the Directorate of Cashewnut Development for finding out the possibility of extending cashew cultivation. Although the estimates do not tally, there is a broad indication that it should not be difficult to find an additional area of the extent estimated here in the various peninsular States and Orissa. Besides bringing in more area under this crop, there is also need to have a calculated planning for gradual shifting of plantations from the existing unproductive sites to highly promising ones both in private as well as forest lands. Insofar as private lands are concerned, certain incentives may have to be designed for this purpose on the same lines as in the case of rubber.

24.3.9 The cashew industry can get a big boost provided the cashew by products could be fully utilised. This aspect is considered in the following subparagraphs :

(i) The nuts in shell, when roasted, give out an oil which is known as the cashewnut shell liquid (CNSL). This oil is 25 per cent of the weight of the nuts in shell. Extraction of CNSL is at present between 10 and 15 thousand tonnes.[1] Internal consumption of CNSL is only 10—15

1 1972. A New Utilization of CNSL Resins—Protection of Thatched Roofs. Cashew Bull. 9 (4).

per cent and the remaining quantity is exported.[1] Internal utilization is mainly for painting fishing boats and nets. The Spices Enquiry Committee had recommended that encouragement be given to indigenous utilization of CNSL. Research work was undertaken in several institutes in the country including the National Chemical Laboratory, Poona, on the uses of CNSL. Among the several important methods developed in these laboratories are the manufacture of anti-corrosive paint, cation exchange resin, tannin and cashewnut gum. The Kerala State Cashewnut Development Corporation has been considering a proposal to instal units for the manufacture of anti-corrosive paint from CNSL during the Fifth Plan period. This is a step in right direction and should be followed by other cashew growing States also.

(ii) The testa of cashewnut yields tannin to an extent of 25 per cent. The Cashew Enquiry Committee (1969) had recommended setting up of a public sector undertaking for the manufacture of tannin from cashew testa. The Kerala State Cashewnut Corporation is considering the manufacture of tannin during the Fifth Plan period and it is desirable that other States should follow suit so that cashew tannin can supplement the tannin requirements of the expanding leather industry.

(iii) The cashew apple is juicy and has a fibrous flesh, when fully ripe the juice is quite sweet but is acrid and acidic in the immature apple. Present production of cashew apple in the country is estimated to exceed 700,000 tonnes.[2] Out of this, only a very small quantity is utilised in Goa for making fermented beverages and vinegar. All the rest is wasted at present or fed to cattle or pigs. Exploratory trials were conducted at the Central Food Technological Research Institute (CFTRI), Mysore, to find out the possibilities of utilizing cashew apple. These investigations indicate the possibilities of preparing a number of products like syrup, brandy, candy and jam after removing the astringent and acrid principles. The Cashew Enquiry Committee (1969) recommended focussing attention on cashew apple utilization research and suggested that a few selected fruit processing units should be entrusted with the job of commercial exploitation of cashew

1 1972. Survey on Utilization of Cashewnut Shell Liquid in India, Cashew Bull. 9(7).

2 As per information furnished by the Directorate of Cashewnut Development, Cochin.

apple. Such units were to be provided with financial assistance for the purpose while the CFTRI and the Directorate General Technical Development, Ministry of Industrial Development & Civil Supplies, was required to provide technical assistance. It is not known how far these recommendations have been carried out but, there is, anyhow, need for a review to implement the recommendation in full.

4 ARECANUT

24.4.1 Arecanut is popular as a masticatory used either with betel leaves or as plain or as scented *supari*. Arecanut has uses in ayurvedic and veterinary medicines because of its several alkaloids, but its utilization in this manner is negligible on the whole. The habit of chewing arecanut is typical of the Indian sub-continent and its neighbourhood. Its demand in other parts of the world is chiefly from the section of the population who migrated originally from this sub-continent. The production of arecanut is also largely confined to this sub-continent. Table 24.4 gives the area under and production of arecanut in the principal growing countries.

TABLE 24.4

Area Under and Production of Arecanut in Principal Growing Countries[1]

area = thousand ha
production = thousand tonnes

Country	Area	Production
India	174	150
Bangladesh	79	57
Sri Lanka	20	57
Malaysia	4	NA

24.4.2 India leads in production, but even then it was never sufficient to meet the internal demand in full until recently. It had to depend upon imports to fill in the gap. The data pertaining to this crop have been collected by the Directorate of Economics and

1 1973. Report of the Committee constituted to study the price structure of arecanut and other allied matters, Department of Agriculture and Forest, Government of Mysore (now Karnataka).

Statistics, Ministry of Agriculture and Irrigation, Government of India, on a systematic basis from 1958-59 and these are presented below[1].

TABLE 24.5

Availability of Arecanut in India

(thousand tonnes)

Years	Production[1]	Imports	Total
1958-59	78	18	96
1959-60	82	14	96
1960-61	95	11	107
1961-62	97	10	107
1962-63	99	9	108
1963-64	98	3	101
1964-65	113	3	116
1965-66	119	3	122
1966-67	130	Neg.	130
1967-68	135	Neg.	135
1968-69	140	..	140
1969-70	138	..	138
1970-71	141	..	141
1971-72	151	Neg.	151

24.4.3 The averages of production and imports are given below for four-year periods ending 1961-62 and 1971-72 :

(thousand tonnes)

Four-year period ending	Production	Import	Total
1961-62	88	13	101
1971-72	143	Nil	143

In the earlier period of 1958-59 to 1961-62, on an average the imports were of the order of 18,000 tonnes, which put the total availability of arecanut in the country at 101,000 tonnes, the per capita annual availability of this commodity working out to 230 grams (on the basis of population of 440 million in 1961-62). With increased production, the imports were gradually eliminated over the next few years. The internal production in the last four years ending 1971-72 was 143 thousand tonnes which gave a per capita availability of 260 grams of arecanut (on the basis of a population of 560 million in 1971-72).

24.4.4 The area, production and yield of arecanut in the country fluctuated within narrow limits between 1958-59 and 1964-65, the averages being 113,000 ha, 95,000 tonnes and 8.4 quintals per hectare respectively. The increases which have accrued in succeeding years

1 Nov., 1972, Estimates of Area and Production of Principal Crops in India, 1971-72; DES.

are shown below :

TABLE 24.6

Area, Production and Yield of Arecanut in India[1]

area = thousand hectares
production = thousand tonnes
yield = q/ha

Year	Area		Production		Yield	
	Actual	% increase over base period	Actual	% increase over base period	Actual	% increase over base period
1958-59 to 1964-65 (base period)	113	..	95	..	8.4	..
1965-66	137	21	119	25	8.7	4
1966-67	142	26	130	37	9.2	10
1967-68	147	30	135	42	9.2	10
1968-69	157	39	140	47	8.9	6
1969-70	161	42	138	45	8.6	2
1970-71	167	48	141	48	8.4	1
1971-72	174	54	151	59	8.7	4

It is evident that increase in production has mainly been due to increase in area. The yield has improved but little; the earlier average was 8.4 quintals per hectare and the maximum in more recent years has been 9.2 quintals per hectare.

24.4.5 Organised research work on this crop is being conducted from the last 30 years or so. The Government of India made a financial grant of rupees five lakhs to the ICAR for the first time in 1945 for financing measures to improve and develop the production and marketing of arecanut. The Indian Central Arecanut Committee (ICAC) was constituted in 1949 on the recommendation of an *ad hoc* committee appointed by the ICAR in 1947. There is at present an All-India Coordinated Project on Arecanut Research, in which all the undermentioned stations are also involved :

A. *Main stations*

(i) Central Plantation Crops Research Institute, Kasaragod (Kerala) CPCRI.

1 Nov., 1972., Estimates of Area and Production of Principal Crops in India 1971-72, DES.

B. *Regional stations of CPCRI*

(ii) Central Aercanut Research Station, Vittal (Karnataka),
(iii) Regional Arecanut Research Station, Hirehalli (Karnataka).

C. *Sub-stations of CPCRI*

(iv) Arecanut Research Station, Palode (Kerala),
(v) Arecanut Research Station, Peechi (Kerala),
(vi) Arecanut Research Station, Sreevardhan (Maharashtra),
(vii) Arecanut Research Station, Mohitnagar (West Bengal),
(viii) Arecanut Research Station, Kahikuchi (Assam),
(ix) Arecanut Research Station, Sipighat (Port Blair—Andaman and Nicobar Islands).

24.4.6 The developmental programme which was formerly being carried out by the ICAR is now attended to by the Directorate of Arecanut and Spices Development with headquarters at Kozhikode. Work on technological aspects of arecanut has been conducted from time to time in different universities and institutes through specific schemes sanctioned in the past by the ICAC. Some of them are mentioned below :

(i) Chemistry of arecanut husk and its destructive distillation, utilization of husk in the preparation of wrapping paper, boards, insulating wool, cellulose plastics, moulding powder, furfural and also by-products of destructive distillation of husk—Forest Research Institute, Dehradun, and the universities of Gauhati (Assam) and Tranvancore (Kerala).
(ii) Utilization of tannins of areca palm and nuts in leather tanning and in the preparation of writing inks—Central Leather Research Institute, Madras and Presidency College, Madras.
(iii) Preservation of areca fruits and husk in fresh condition—Tranvancore University and Central Food Technological Research Institute, Mysore.
(iv) Chemical constituents of areca palm and nuts, isolation of alkaloids including their individual components and testing their pharmacological action and therapeutic uses—universities of Calcutta, Aligarh, Annamalai and Andhra Pradesh.
(v) Utilization of arecanut in the preparation of dentifrice—Calcutta Chemical Ltd., Calcutta.
(vi) Drying of arecanuts—Central Food Technological Research Institute, Mysore.

Although the technological work has been done in the past in a scattered manner on an *ad hoc* basis and this may remain unavoidable to some extent in future too, it is expected that many problems on the side of utilisation will also be attended to in future.

24.4.7 As a result of research work, a few exotic varieties of arecanut have been identified for better performance over the local ones. Mangala, an introduction from China has already been released for cultivation. Studies have been made on methods of raising plants, selection of seed nuts and seedlings, NPK requirements, water management, mixed cropping and pests and diseases. Majority of the growers in Karnataka have been in a position to derive benefit from such studies but the same cannot be said about planters in other parts and this aspect has been discussed in the next paragraph. Many nurseries exist for raising seedlings and supplying the same to growers, but plantations at large are heterogeneous in nature and contain low yielding types. Diseases like *anable* (foot rot), *koleroga* (fruit rot) yellow-leaf and band disease and pests like root grub, spindle bug and inflorescence caterpillar continue to take a heavy toll of the crop.

24.4.8 Statewise average annual area and production in the period 1969-70 to 1971-72 are presented below :—

TABLE 24.7

Statewise Area, Production and Yield of Arecanut in India[1]

area = thousand ha
production = thousand tonnes
yield = q/ha

State	Area		Production		Yield
	actual	% of all India	actual	% of all India	
Kerala	85.4	51.0	52.8	36.9	6.2
Karnataka	40.9	24.4	52.5	36.7	12.8
Northeastern States	29.8	17.8	29.9	20.9	10.0
Tamil Nadu	4.3	2.6	2.6	1.8	6.0
West Bengal	3.1	1.9	0.8	0.6	2.6
Maharashtra	2.3	1.4	3.0	2.1	13.0
Goa, Daman & Diu	1.4	0.8	1.3	0.9	9.3
Andhra Pradesh	0.2	0.1	0.2	0.1	10.0
all-India	167.4	100.0	143.1	100.0	8.5

24.4.9 The data available for Sri Lanka indicates that the yield of arecanut is about 30 quintals per hectare. In Karnataka also, yields up to 30 quintals/ha are not uncommon in individual plantations. This should indicate the highest potential which can be aspired for in the case of this crop. However, taking a practical view, a yield target of 15 quintals per hectare can be assumed for Kerala and 20 quintals

1 Nov., 1972, Estimates of Area and Production of Principal Crops in India 1971-72, DES.

for Karnataka and North Eastern States. This will mean a production of about 270,000 tonnes from the existing area of arecanut in these parts, giving an overall yield of 16 q/ha. Calculating the demand for the adult equivalent of the population in 2000 AD at the rate of 250 grams per head per year, the requirement of arecanut works out to be about 190,000 tonnes, leaving a surplus of about 80,000 tonnes for utilization in medicinal and other kinds of industrial needs and for export. It may be mentioned that processed cut *supari*, scented or otherwise, which is popular in many of the peninsular States, is a speciality of India which can profitably be exported to those countries where there is a large section of population of Indian origin. If there remains any unutilized surplus, a reduction in area may be thought of at a later stage. Considering the present extent of area under this crop, we are of the opinion that the existing research or developmental setup in the States and at the Centre should be sufficient. What is needed is to develop high yielding varieties as well as the accompanying package of practices. The Central Plantation Crops Research Institute together with its regional and substations should be in a position to seek cooperation of the agricultural universities of the States concerned. It will also be advantageous to get the available requisite know-how from Sri Lanka for improving the standard of production.

5 COCONUT

24.5.1 Coconut palm is one of the very versatile plants; almost every part of it is put to some use or the other. About 95 per cent of the fruits seem to be consumed in the form of tender nuts and copra (Appendix 24.3—Statement I), the balance being used for oil extraction. Its leaves are put to use in the preparation of baskets, hats, umbrellas and broom sticks but the coconut fibre is the most important of all its by-products, because this serves as a raw material for the coir industry. The current position of area and production of coconut is indicated in Appendix 24.3—Statement II. The total all-India production is about 6,000 million nuts. Kerala accounts for about 67 per cent, Tamil Nadu 16, Karnataka 11, Andhra Pradesh about 3 and the rest of 3 per cent is distributed along the west coast or east and northeastern parts. As far as yield performance, is concerned, it varies from about 3,000 to 10,000 nuts per hectare giving an all-India average of 5,700 nuts per hectare. Tamil Nadu records over 9,000 nuts/ha, the main producing State of Kerala about 6,000 and the remaining important growing States between 4 and 5 thousand nuts per hectare. Appendix 24.3—Statement I would show that the nut

equivalent of one tonne of copra is 7,000 for the indigenous fruits, whereas it is 5,000 for the imported ones.

24.5.2 Research on coconut was initiated as early as 1916 at Kasaragod and Nileshwar by the then Madras Department of agriculture. It was only around 1935, when the root and leaf diseases became rampant in parts of Travancore, that the crop drew notice of the ICAR and the State of Travancore and Cochin also became specially alert. The ICAR assisted the then State of Madras also in 1937 to fight the menace of fruit drop or button shedding. Selection of quality seedlings for planting and the quality of coconut husk at different stages of maturity of the fruit also received attention. The Indian Central Coconut Committee was constituted in 1945 for the development of production and utilization of coconut on sound economic lines. Kayangulam and Kasaragod were converted into the Central Coconut Research Stations in 1947-48. Kasaragod was charged with the responsibility of attending to problems of fundamental nature relating to breeding and agronomy, whereas Kayangulam was made responsible specifically for studying various diseases and pests of coconut and evolving control measures. Many regional research stations were also established during the period 1955—58 in order to cater to local problems in the coconut cultivating States (Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Orissa and Assam) under the joint auspices of the Committee and the State Governments concerned. The Indian Central Coconut Committee was abolished in 1966 and in 1970 a Central Plantation Crops Research Institute was organised by the ICAR bringing within its purview the activities of the two Central stations mentioned earlier. The Central Arecanut Research Station at Vittal together with its regional stations also came under this Institute and this network has also been participating in coconut research work. Andaman Islands have a Coconut Research Station at Sipighat and a station is being established in the Lakshdweep Islands also. Agricultural Universities situated in Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat and West Bengal are also participating in coconut research. For coconut in Karnataka, there is a station at Arasikere under the University of Agricultural Sciences, Mysore, Bangalore. In Tamil Nadu, there is a Research Station at Pattukota (Tanjore District) under the Department of Agriculture. The existing net work of research stations also participates in the Coordinated Project for Arecanut and Coconut Development which was initiated in 1970.

24.5.3 A summary of the salient features of research work done so far is presented below :

(i) One of the important outcomes of research work relates to breeding of hybrids between tall and dwarf varieties.

The natural cross dwarf hybrids (NCD), being tolerant to root wilt, are capable of giving about twice the normal yield. The copra content per nut is also higher.

(ii) The use of sea water for irrigating coconut palm is found to improve the productivity without any evidence of bad effect in light soils; heavy soils do experience some deleterious effects. This finding can be put to use advantageously in light soils in coastal areas during summer season, where there is dearth of irrigation water.

(iii) The leaf-eating caterpillar, *Nephantis serinopa,* Rhinocerus beetle and cockchafer grub have also engaged attention. *Nephantis* is found to be amenable to biological control through the use of various insect parasites.

24.5.4 The Directorate of Coconut Development, which came into existence in 1966 and the Indian Coconut Development Council have been making endeavours with the cooperation of the States concerned to popularise better varieties and better methods of cultivation all along. There have been special schemes to produce and distribute hybrid seedlings. However, the efforts have not matched with the demand. In order to fill in this lacuna, the State Governments are already thinking of establishing adequate number of seed farms. The State Governments have also tried to provide financial assistance in the form of subsidy on plant protection chemicals and fertilizers and necessary demonstrations have also been arranged to enable growers to take to better methods of cultivation. Only 10 per cent of the total area of coconut could be brought under improved practices so far. The following data would reveal that the increase in production has largely been due to increase in area:—

TABLE 24.8

Area, Production & Yield of Coconuts in India[1]

area = thousand ha
production = million nuts
yield = nuts/ha

Quinquennium ending	Area	Production	Yield
(1)	(2)	(3)	(4)
1955-56	647	4,226	6,532
1960-61	717	4,639	6,470
1965-66	884	5,035	5,698
1970-71	1,046	6,075	5,811

24.5.5 A declining trend is discernible in coconut yield in the above data. New plantations which have not attained full bearing

1 Nov., 1972, Estimates Area and Production of Principal Crops in India—1971-72, DES.

capacity might be responsible partly for lower averages in recent times, but the chief reason for such a state must lie in the existence of degenerated plantations infested with pests and diseases. A systematic plan of underplanting the existing plantations with the new hybrids/varieties has to be implemented with speed so that uneconomic trees could be cut off in course of time. Wherever it is felt that the existing plantations have to be shifted to new sites, this might also be done. A system of replanting subsidies could be introduced for this crop just as in the case of rubber plantations. A vigorous extension programme is also required alongside in order to educate the growers in the use of better cultural and plant protection techniques. The importance of attending to individual trees has to be properly emphasised in the case of this crop. Moreover, the fertility status of the soil in general in coconut plantations should also be increased by resort to green manuring. From the Government point of view, it is worth noting that giving replantation subsidies, specially for improved types like tall dwarf crosses, will be a short term liability, because the hybrids start yielding much earlier than the traditional trees. Besides subsidy, it will be necessary to ensure that all the inputs, i.e., quality seedlings, fertilizers and plant protection chemicals are duly provided. A sizeable area in the case of this crop comes from household plantations and, therefore, a programme on the lines suggested for pepper for providing chemicals in small packets to be within easy reach of an ordinary grower may be considered in this case too. If all these measures are ensured, the existing area of 1.05 Mha itself will be in a position to give a production of about 12,000 million nuts, giving an average yield of about 11,400 nuts per hectare by 2000 AD. It should then be possible not only to do away with the import of copra, which is being made at present, but also to enable the country to enter the export market. The nut equivalent of copra imported at present from other countries, mainly Sri Lanka, is of the order of 75 million.

24.5.6 India is a member of the Asian Coconut Community, which was set up in September 1969 with headquarters at Djakarta with a view to promote, coordinate and harmonise all activities of the coconut industry for achieving maximum economic development. It is one of the objects of this body to identify common problems and evolve common solutions for bettering production standards. A permanent panel on coconut production and productivity has already been set up with the aid of United Nations Development Programme for this purpose. The studies undertaken relate to the use of planting material of high intrinsic value, field culture and maintenance of adult plantations. It is expected that India, as a member, will be able to benefit from this body in various directions in due course.

6 OIL PALM

24.6.1 Oil palm or 'red oil palm' (*E. guineensis*) is a native of West Africa. The introduction of oil palm into India was made initially by the Indian Central Oilseeds Committee in the fifties, but its cultivation has not expanded to any significant extent. Oil palm fruit is made up of a pulpy pericarp (63 per cent), a thick shell (27.3 per cent) enclosing three kernels (9.2 per cent). The pulp contains 75-80 per cent oil and the kernel 45 per cent oil. These oils are respectively known as 'palm oil' and 'palm kernel oil' and marketed separately. Palm kernel oil resembles coconut oil more than palm oil. The latter is more akin to tallow. Both the oils are used in soap, margarine or shortening manufacture. Palm oil contains carotenoids and vitamin A and is thus preferable for edible purposes. It is also used in hot dip tin plating industry. Palm kernel oil can be used in the manufacture of synthetic detergents as well as in confectionary articles, biscuits, bakery or even ice cream. It is a good source of lower fatty acids like caprylic and capric acids. Palm oil and palm kernel oil account for 5.5 per cent of the world's production of all fats—vegetable, animal and marine. Palm oil is the only vegetable oil with vitamin A content comparable to that of codliver oil and ten times richer than butter. Currently, palm oil is imported into the country and it is used exclusively for industrial purposes. About 32,000 tonnes of this oil were imported in 1972-73 at a cost of Rs. 5.7 crores. There is need to do away with this import as far as possible.

24.6.2 Oil palm begins to bear when 4 to 6 years old and reaches full bearing at 14-15 years of age. It can yield 2.75 tonnes of oil per hectare per year from the fifth year onwards. The yield of fruit begins to decline after 30 years, when replanting becomes necessary. Owing to long life and high oil content, it is not easily excelled by any other member of the plant kingdom in oil production. There are four economic varieties, viz., Macrocarpa, Dura, Tenera and Pisifera, which are distinguished on the basis of varying thickness of shell and pericarp of the fruit. Four thousand hybrid seeds from Dura x Dura, Dura x Pisifera and Dura x Tenera crosses were imported from Nigeria in 1964 and planted in Kerala. Observations made so far indicate that Dura x Pisifera hybrids are promising with reference to germination, growth and number of bunches of female flowers. Agronomic experiments indicate that magnesium is also required along with nitrogen, phosphorus and potash. Spacing of seedlings 6 metres apart and a planting depth of 1 metre appear to yield the best results.

24.6.3 Oil palm thrives best between latitudes 16°N and 12°S in regions of high rainfall (200 cm annual) and high humidity (say of

over 70 per cent Relative Humidity). Clay loams are said to suit it. According to Fifth Five Year Plan proposals, a programme for raising 2,000 hectare plantation of oil palm in Kerala, which was initiated in 1969-70, is expected to be completed in 1975-76. The programme is being carried out by the State-owned Plantation Corporation of Kerala Ltd., with the participation of the Central Government. Another project for raising 2,400 hectare plantation in the Andaman and Nicobar Islands is expected to be completed by the end of the Sixth Five Year Plan. The Tallow Funds lying with the Basic Chemicals, Pharmaceuticals and Soap Export Council of the Ministry of Commerce are being utilized for encouraging all these plantations. While developing block plantations of oil palm under public sector, attention is also being paid to develop oil palm cultivation on small holders' fields. A target of 400 hectares each for Kerala and the Andamans has been fixed for the Fifth Five Year Plan period. It has been envisaged to provide incentives by way of technical guidance and planting material (8—12 months old seedlings raised by the Department of Agriculture in Kerala and Andamans) free of cost.

24.6.4 It may be observed that the plantations of oil palm are at present being contemplated only in Kerala and the Andamans and the area proposed is 5,200 ha. There is a possibility of congenial sites being available in the coastal and adjoining areas of Karnataka and it remains open for verification whether the tree could succeed even in Lakshadweep Islands. Because of the quality of oil and its various uses, this tree could prove very helpful in supplementing the resources of vegetable oil of this country provided that its cultivation assumes some tangible proportions. Therefore, it would be worthwhile for the ICAR to conduct experiments not only to locate congenial areas but also to explore as to how best it could be made possible to cultivate this tree within the limitations of the prevalent agro-climatic conditions. However, it is difficult to envisage at present an area of more than about 25,000 ha under this crop in 2000 AD even with the most optimistic estimates. Thus, the yield of oil with a moderate recovery of 2 tonnes per hectare per year would come to about 50,000 tonnes at the most. Feasibility trials for area expansion even on the contemplated modest scale will have to be planned right from now because of the time factor involved between plantation and fruiting. Provision will have to be made for large scale as well as small scale plantations. The most important input in the initial stages will be the supply of 8 and 12 months' old seedlings. The high yielding Dura x Pisifera hybrids are available in Malaysia or Indonesia, but it may not be possible to rely on these sources owing to various reasons. Therefore, what will be required to be done will be to organise nurseries from the

material which has already come and has been established within the country. Another important constraint which is to be removed to make this crop popular pertains to oil extraction. The fruits of oil palm cannot stand long distance transport or long time storage and consequently the pulp has to be deoiled almost immediately after harvest. Because of this difficulty, planters often resort to *in situ* extraction by mashing and boiling with water, but this is a wasteful process involving loss of oil to an extent as high as 70 per cent. In order to wean away people from this practice, it is desirable that extraction plants are located close to plantations and one will also have to plan for efficient methods of extraction; solvent extraction and centrifugal method of extraction are the most efficient processes yielding more than 90 per cent of the oil content. Insofar as scattered small plantations in house compounds etc. are concerned, it will be necessary to organise some rapid collection service for fruits.

7 CLOVE AND NUTMEG

24.7.1 Clove (*laung or lawanga*) and nutmeg (*jaiphal*) both belong to the family Myrtaceae, the former belonging to the genera *Eugenia* and the latter to *Myristica*. Both of these are the best known among the tree spices. Clove of commerce is really the unopened dried floral bud. The nutmeg proper is the seed of the fruit. The dried aril of nutmeg, known as mace (*javitri*) is also important. The country has to depend mainly on imports of these two spices, 236 tonnes cloves worth Rs. 30 lakhs annually and 57 tonnes nutmeg worth Rs. 8 lakhs annually, average during 1967-68 to 1971-72. The countries which mainly provide these commodities to India are Malaysia, Singapore and Indonesia. Besides being spices, clove and nutmeg have the following other uses :—

(i) Clove is a common masticatory used independently or in combination with *pan* and *supari*. Clove yields an oil to the extent of 18 to 20 per cent of its dry weight. Clove stems and leaves also yield the oil but the percentage is only about 5 and the quality is also inferior. The oil is useful in dental ailments and in microscopy as clearing agent. It is also a source of artificial vanillin.

(ii) Nutmeg and mace are used in domestic medicines, commonly against cold. Fresh husk of the ripe fruit is useful in preparing jellies. Nutmeg is used for flavouring dental preparations and confectionary articles also. The leaves of nutmeg tree are distilled to obtain an oil which has medicinal properties.

Both these trees were introduced for cultivation in India from the Moluccas Islands in the eighteenth century by the East India Company. The main features of these crops are considered in the succeeding paragraphs.

Clove

24.7.2 This tree was first established around Courtallam in Tirunelveli district. Gradually, clove cultivation was introduced as a subsidiary crop in coffee estates, as individual trees and in block plantations. The main concentration was in the Nilgiris and the hills of Travancore. Linking of clove cultivation with coffee was disastrous, because when coffee estates were neglected or abandoned, clove trees were also disowned and got absorbed in the jungles in course of time. The survey conducted by the ICAR in 1960 estimated the tree population in the growing areas of South India around 5,000.[1] From the viewpoint of cultivation, the clove plant is not very exacting as to soil conditions, but it does require a rainfall of about 150 cm. fairly well distributed over the year. The tree is not likely to grow in any part of India with either a long hot dry season or a very low temperature. According to the ICAR survey, hill regions in the south-west of India ranging from 300 to 900 metres covering parts of Kerala, Tamil Nadu and Karnataka are more favourable for clove growing than the lower elevations of the coastal belt. Possibly, the Islands of Andaman and Nicobar could also suit. It is necessary to search for suitable areas in these parts and extend cultivation of this tree so as to do away with imports in course of time. Clove plantations can be pure or mixed, the trees being interplanted in the existing coconut and arecanut plantations and fruit orchards or as shade trees, windbreaks and avenue trees on roads. Individual trees could be encouraged even in the compounds of private houses.

24.7.3 The existing position is that the clove tree gives highly variable yields. There may be negligible yield from almost sterile trees on the one hand and as much as 120 kg of dry cloves from fully bearing trees on the other. Besides, clove is an irregular bearer, years of good yields alternating with years of moderate or poor yields and with years of no yields with no indications of any regular periodicity. The problems of sterility and periodicity have to be studied and solved through research. Absence of suitable methods of vegetative propagation and limited range of genetic variability are the other difficulties in the improvement of this crop. Research work done at Burliar and

1 1938. Aiyer Yogna Narayan, A.K., Cultivation of Cloves in India, revised by P. Abraham, 1960 New Delhi, Indian Council of Agricultural Research.

Kallar Gardens in the Nilgiris has shown that inarching is possible in the case of clove, which is compatible on its own rootstock. Advantage could be taken of this finding for multiplication work. It is also necessary to evolve a method for increasing germination of clove seed as well as for establishing plants without incurring serious loss through death, the death rate of seedlings being very high at present. Techniques in respect of training and pruning trees to induce formation of low broad bushy crowns, which can be easily reached for picking, manuring and irrigation have also to be evolved. In addition, manuring and irrigation requirements have also to be determined.

Nutmeg

24.7.4 The cultivation of nutmeg has also made little progress and is confined to South India. Total area under nutmeg does not exceed 12 ha. The climatic and soil requirements of this tree are similar to clove and, therefore, an attempt has to be made to extend its cultivation along with that of clove. The extension of area should be sufficient to do away with the imports. It may be pointed out at this stage that about 5 lakh seedlings of clove and nutmeg are being contemplated to be provided for planting purposes during the Fifth Five Year Plan period. The target for these two crops will have to be increased from the Sixth Plan onwards if our suggestion to make the country self-sufficient with regard to these two crops has to be realised by 2000 AD. The main difficulty lies in the dioecious nature of the plant. Since male plants can be recognised only after flowering, all plants have to be maintained in the early stages of the plantation and this becomes a wasteful expenditure. Identification of sex of seedlings before planting will be very useful. Conversion of male plants into females by suitable techniques is another line for research which could prove useful in establishing fruit bearing plantations early and at a cheaper cost. Budding, grafting and airlayering have been attempted in various parts of the world. About 60 per cent success with approach-grafting on rootstocks of *Myristica malabarica* and *M. beddomeii* has been reported in India under experimental conditions. Under ordinary conditions, however, it is not so easy to maintain the stock in position during the period of grafting because of its slender nature. Secondly, the performance of grafted material still requires to be established, which will certainly take a long time. Therefore, research work on vegetative propagation is required to be pursued. Both for this crop as well as for clove, it will be advantageous if the experts in the agricultural universities of Kerala, Tamil Nadu and Karnataka can chalk out a common strategy.

8 CACAO (COCOA)

24.8.1 The popularly known cocoa is derived from the beans of the cacao tree (*Theobrome cacao*). Cacao thrives in humid tropics. World production of cacao is 1.5 million tonnes annually and the major countries which account for about 80 per cent of the world production are Ghana, Nigeria, Ivory Coast, Cameroon and Brazil. Cacao was originally introduced into India by the East India Company towards the end of the eighteenth century. The oldest existing plantation is at the Kallar Fruit Research Station in the foothills of the Nilgiris. Some of the trees were planted at this Station in 1930—35 and these provided much of the planting material used in India in later years. Cacao remained a garden plant virtually up to 1950. However, beans obtained from the few scattered plantations within the country were found to be even superior to those produced in other countries. This aroused interest in growing cacao on a large scale. Research and developmental activities were then initiated in Tamil Nadu. The ICAR constituted an *ad hoc* Committee in 1962 to draw up a coordinated policy on the development of cacao in the country. Messrs Cadbury Fry (India) Private Ltd. had lent the services of one of their cacao experts to give his views on the potentialities of this crop in this country. It was reported that the Andaman & Nicobar Islands provided the best area for its cultivation. In the mainland, the required favourable conditions were found to exist in the Peninsula, Orissa, Assam and Tripura. The choice ultimately narrowed down to the southern-most States of Karnataka, Tamil Nadu and Kerala. The Department of Horticulture in Karnataka and Departments of Agriculture in Tamil Nadu and Kerala produce seedlings in a few nurseries and maintain staff for developmental work. The ICAR is at present responsible for research work, which has been entrusted to the Central Plantation Crops Research Institute, Kasaragod (Kerala). Attempts are being concentrated on breeding and selecting suitable varieties for Indian conditions.

24.8.2 Messrs Cadbury Fry (India) Private Limited have also been evincing interest in the developmental work. Their principals in the United Kingdom used to obtain raw material from Africa, but they were interested also in locating and developing alternative sources of supplying for their expanding business. In 1965, this company took interest in extension work with a view to develop cacao production in this country and began to import seed material and produce seedlings for distribution. It has its own stations for this purpose at Glencoorg in South Kanara (Karnataka), Kulasekaram in Kanya Kumari (Tamil Nadu) and Chundale in Wynad (Kerala). These stations also serve

as demonstration farms. The company operates its own free cacao advisory service. The company has buying centres at several places as a part of its extension network. These buying centres have proved of considerable help to individual growers who produce small quantities of beans and are, therefore, not in a position to process them. The company's extension work is organised in collaboration with the Ministry of Agriculture and Irrigation, the ICAR and the concerned State departments.

24.8.3 The production of beans within the country is negligible at present. The firms which manufacture cocoa products import beans from outside. The consumption of beans in factories is at present about 800 tonnes per annum, but there is a vast scope for the utilization of cocoa products for internal consumption as well as export. The area under cacao is 1,200 ha at present in the three southern States. Most of the plantings have been done during the last three years and are in prebearing stage. Considering that even if it is possible to plant about 500 to 600 ha under cacao every year, the area which would have developed under this crop by 2000 AD will be around 15,000 ha. The yield of cacao beans varies with age. Fairly good yield is 1000 kg/ha if it is a mixed crop and 2000 kg/ha if it is a pure crop. Being a new crop, it is difficult to anticipate its performance in mass scale cultivation here. But even with an yield of 1 tonne/ha the production in 2000 AD will be 15,000 tonnes. It might be worthwhile to study whether parts other than Andaman and Nicobar Islands, Karnataka, Tamil Nadu and Kerala, particularly Orissa, can also go in for this crop. Cacao is grown in Kerala as one of the plants in mixed cropping. There may be a future for such a mixed plantation in other parts like Karnataka and Tamil Nadu hill areas. If small farmers really get attracted to take up this crop in their mixed cropping systems, a common service for processing the beans will become necessary; so also a common service for plant protection operations.

24.8.4 We attach considerable importance to the fact that the seed requirements for this crop must be met from indigenous production. The first essential requirement is, therefore, to produce the required quantity of seed. The multiplication ratio of this crop which varies with age because of gradual increase in production could be assumed as under :—

Age (years)	Multiplication Ratio
6	50
7	80
8	120
9	120
10	120
12	300

In order to facilitate calculations, a round value of hundred may be assumed for multiplication ratio. On this basis, the area required to produce to requisite quantity of seed material will be 150 ha. The plantations which have already been established in 1,200 hectares will be able to commence yielding adequate quantities of beans with effect from the year 1977. If an area of 150 hectares can be reserved out of those, it can suffice to serve as the basis for future plantations in the country including the Islands of Andaman & Nicobar. What is needed for seed production is to select the best possible locations of growth within the existing cacao plantations distributed in different States. The selected units of plantations should be given all special attention which is inherent in a seed production farm. It appears very necessary that in order to manage the seed production programme, the States concerned should seek the cooperation of the CPCRI, Kasaragod for which purpose a separate unit should be added to it, adequately staffed with trained personnel. This programme of propagation through seed should be deemed to be an immediate solution, though chances appear promising for vegetative propagation. The work in this regard is being attempted in Africa and it should be a challenging task for the Indian scientists too.

24.8.5 The second step in planning will be to establish nurseries which should be sufficient to provide seedlings for planting the whole of the targetted area of 15,000 ha according to a phased programme. It will be advisable that the Andaman and Nicobar Islands and the concerned States should have their own nurseries sufficient for their areas. The third step will be to locate areas in different States where the plantations are going to be established. We are of the opinion that preliminary action should be taken for the second and third steps right from now by the State Governments concerned with the assistance of the Union Ministry of Agriculture and Irrigation and the ICAR. It should be kept in view that cacao can be successfully planted as a mixed crop also with coconut and, therefore, a proper balance may be kept between pure and mixed plantations.

9 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

24.9.1 The main recommendations are as under :

1. The targets of area for the various plantation crops for 2000 AD are given in Appendix 24.4. Main proposals for area extension are :—

(i) Out of the proposed 175,000 ha additional land to be

brought under rubber crop, 100,000 ha be earmarked for the North Eastern region and the remaining 75,000 ha could be spread over congenial locations along the Western Ghats. Areas could be sought for even in Andhra Pradesh and Orissa.

(Paragraphs 24.2.12 & 24.2.13)

(ii) It is possible to increase the area under cashewnut in the Peninsular States and Orissa. Besides thinking of absolutely new areas for this crop, the plantations from the existing unproductive sites should also be shifted to highly promising ones, both in private as well as in forest lands. Insofar as private lands are concerned, certain incentives like the replanting subsidies, as in the case of rubber, could be given for this crop too.

(Paragraph 24.3.8)

(iii) The ICAR should arrange to conduct feasibility trials on oil palm in the areas which are thought to be congenial. Side by side, it would also be worthwhile to find out experimentally the manner in which the tree could be grown successfully within the limitations of the agro-climatic conditions prevailing in the country.

(Paragraph 24.6.4)

(iv) Congenial conditions for the cultivation of clove and nutmeg exist in the hill regions of Kerala, Tamil Nadu and Karnataka. It is necessary to undertake cultivation of these spices to an extent sufficient to replace their imports. The possibility of their cultivation in the Islands of Andaman and Nicobar should also be explored.

(Paragraph 24.7.2)

(v) Besides the Andaman and Nicobar Islands and the States of Karnataka, Tamil Nadu and Kerala, it is worthwhile to examine whether cacao plantations could be established in other parts also, particularly, Orissa.

(Paragraph 24.8.3)

2. A special programme for the supply of fertilisers and plant protection chemicals in small packets should be started for the benefit of small pepper growers.

(Paragraph 24.1.9)

3. The Rubber Board's schemes for assistance for rubber plantations should be so modified that small growers get due benefit. They should be given all possible facilities by the institutionalised agencies for which it might be necessary to organise them into effective cooperatives. Cooperatives and other kinds of Farmers' Service Societies

may be created with State support in order to assist small growers in plant protection measures or processing of latex.

(Paragraph 24.2.10)

4. Attempts should be made to breed varieties of rubber resistant to abnormal leaf-fall and powdery mildew. It is also necessary to breed special varieties for the proposed new areas in the States of Maharashtra, Andhra Pradesh and Orissa, which represent comparatively less humid conditions than Kerala and Assam.

(Paragraphs 24.2.5 & 24.2.13)

5. In the existing private rubber plantations, the technical competence of management can be gradually improved by encouraging the dependents of growers to go in for agricultural education. It is also worth examining whether agricultural graduates could be given preference in new areas meant for rubber plantations.

(Paragraphs 24.2.11 & 24.2.13)

6. Increasing the proportion of hermaphrodite flowers and removing other defects should be given priority in research work on cashewnut. It is also very necessary that the existing high yielding varieties are first experimentally tried for their suitability to different agroclimatic conditions before being recommended for adoption.

[Paragraph 24.3.4(i)]

7. If the technique of *in situ* grafting proves successful, it could be adopted for interplanting in cashew plantations so that the unproductive trees can be removed ultimately.

[Paragraph 24.3.4 (ii)]

8. It is necessary to effect proper coordination between the State Departments of Agriculture/Horticulture and forest for carrying out all activities pertaining to cashew improvement on common lines. The former should pay attention to yield aspect rather than laying emphasis merely on soil conservation, whereas the latter should bestow attention on this crop in the same manner as is given to any plantation crop. Besides other applicable scientific methods, the existing trees—whether in forests or elsewhere—should be improved through the technique of top-working.

(Paragraph 24.3.7)

9. It is necessary that the cashew apple, the shell liquid and the testa tannin should be fully exploited industrially in future. Recommendations, which have been made by the earlier committees and are lying unimplemented, have to be freshly considered and new avenues should also be quickly explored.

(Paragraph 24.3.9)

10. The development of high yielding varieties and accompanying package of practices deserve attention in the case of arecanut. The

Central Plantation Crops Research Institute, Kasaragod together with its regional and substations should try to seek cooperation of the agricultural universities of the States concerned. It will be advantageous in research work to get the requisite knowhow from Sri Lanka for improving the standard of production.

(Paragraph 24.4.9)

11. Sea water should be tried to irrigate coconut plantations in light soils in coastal areas during summer season.

[Paragraph 24.5.3(ii)]

12. The existing low yielding plantations of coconut should be rapidly replaced by resort to (a) underplanting with new hybrids/ varieties and (b) by change to new sites according to need. The emphasis has to be on giving attention to individual trees as well as to the plantation as a whole. Extension campaigns have to be conducted in order to educate the growers in the advantages of utilising the new agronomic and plant protection methods coupled with the use of new hybrids/varieties. The State Governments may provide plantation subsidies and input materials. Supply of fertilisers and plant protection chemicals in small packets would prove very helpful to individual household growers.

(Paragraph 24.5.5)

13. The seed of oil palm for planting has to be multiplied within the country itself in order to avoid reliance on imports. Extraction plants are required to be established in close proximity of the growing areas in order to avoid deterioration of the kernels during transport or storage. Arrangements have also to be made to organise quick collection of fruits from small individual growers too. Proper extraction machinery is also a necessity.

(Paragraph 24.6.4)

14. Sterility, irregular annual fruiting and the absence of suitable methods of vegetative propagation are some of the difficulties in the case of clove, which have to be solved through research. It is also necessary to evolve methods for increasing germination of clove seed and reducing mortality of seedlings. Techniques in respect of training and pruning of clove trees in order to induce formation of low broad bushy crowns have also to engage attention. In addition, manuring and irrigation requirements have also to be determined.

(Paragraph 24.7.3)

15. The problem of identification of sex of seedlings of nutmeg before planting needs attention. The possibilities of conversion of male plants into females by suitable techniques as well as the various methods of vegetative propagation should be studied.

(Paragraph 24.7.4)

16. Cacao growing could be encouraged as a part of mixed plantations and when this is achieved, a common service for plant protection operations and processing of beans may be organised to assist the small growers.

(Paragraph 24.8.3)

17. It is advisable to select 150 ha for seed nurseries in the best possible locations out of the existing 1,200 ha of cacao plantations. This seed production programme should be conducted in the concerned States with the cooperation of the Central Plantation Crops Research Institute, Kasaragod and the seed material so produced should be made available to meet the need of Andaman & Nicobar Islands too. Besides propagation through seed, the possibility of clonal propagation should also be experimented with.

(Paragraph 24.8.4)

18. When the availability of cacao seed has been ensured, seedling nurseries should be established in all producing areas of the country. Planning for the nurseries and the actual plantation areas should start right from now. The Ministry of Agriculture and Irrigation and the Indian Council of Agricultural Research should render all help to the concerned States in this work.

(Paragraph 24.8.5)

APPENDIX 24.1

Rubber

(Paragraph 24.2.7)

Statement I—Role of Small Holdings and Estates in Rubber Production

area = thousand ha
production = thousand tonnes
yield = q/ha

Year	Number		Area		Average area per holding (ha)	Production		Yield
	actual	per cent of total	actual	per cent of total		actual	per cent of total	
			small holdings					
1960-61 . .	57,174	99	76	59	1.33	7	27	0.9
1965-66 . .	75,504	99	102	62	1.35	20	40	2.0
1966-67 . .	81,688	99	108	63	1.35	24	44	2.2
1967-68 . .	92,731	99	117	65	1.32	30	47	2.6
1968-69 . .	99,450	99	122	65	1.23	36	51	2.9
1969-70 . .	106,825	99	131	67	1.23	44	54	3.4
			estates					
1960-61 . .	547	1	53	41	96.89	19	73	3.6
1965-66 . .	636	1	63	38	99.06	30	60	4.8
1966-67 . .	647	1	63	37	97.37	31	56	4.9
1967-68 . .	654	1	65	35	99.39	34	53	5.2
1968-69 . .	640	1	65	35	101.56	35	49	5.4
1969-70 . .	647	1	66	33	102.00	38	46	5.8
			all holdings (total)					
1960-61 . .	57,721	100	129	100	2.23	26	100	2.0
1965-66 . .	76,140	100	165	100	2.17	50	100	3.0
1966-67 . .	82,335	100	171	100	2.08	55	100	3.2
1967-68 . .	93,385	100	182	100	1.95	64	100	3.5
1968-69 . .	100,090	100	187	100	1.71	71	100	3.8
1969-70 . .	107,472	100	197	100	1.83	83	100	4.2

APPENDIX 24.1 (Contd.)

(Paragraph 24.2.8)

Statement II—Statewise Area and Production of Rubber

area = thousand ha
production = thousand tonnes
yield = q/ha

Year	Area		Production		Yield
	actual	per cent of all India	actual	per cent of all India	
(i) Kerala					
1965-66	154.88	94.03	46.03	92.91	3.03
1966-67	161.07	94.05	50.49	92.90	3.13
1967-68	169.65	93.65	59.98	93.04	3.54
1968-69	174.73	93.18	66.47	93.55	3.80
1969-70	182.53	92.80	76.90	93.84	4.21
(ii) Tamil Nadu					
1965-66	7.82	4.75	3.20	6.33	4.10
1966-67	8.08	4.72	3.93	7.17	4.86
1967-68	8.35	4.60	4.05	6.28	4.85
1968-69	9.25	4.93	4.10	5.77	4.43
1969-70	9.85	5.01	4.53	5.53	4.60
(iii) Karnataka					
1965-66	1.76	1.07	0.38	0.75	2.16
1966-67	1.84	1.07	0.40	0.73	2.17
1967-68	3.16	1.74	0.43	0.67	1.36
1968-69	3.10	1.65	0.47	0.66	1.52
1969-70	3.74	1.90	0.52	0.63	1.39
(iv) all-India					
1965-66	164.71	100.0	50.53	100.0	3.07
1966-67	171.26	100.0	54.82	100.0	3.20
1967-68	181.59	100.0	64.47	100.0	3.55
1968-69	187.51	100.0	71.05	100.0	3.79
1969-70	196.70	100.0	81.95	100.0	4.17

APPENDIX 24.1 (Concld.)

(Paragraph 24.2.8)

Statement III—Statewise Tappable Area, Production and Yield of Rubber

area = thousand ha
production = thousand tonnes
yield = q/ha

Year	Area actual	Area per cent of all India	Production actual	Production per cent of all India	Yield
(i) Kerala					
1965-66	106.62	94.61	46.95	92.91	4.40
1966-67	107.30	94.54	50.49	92.10	4.70
1967-68	111.40	94.65	59.98	92.75	5.38
1968-69	116.93	94.82	66.47	93.55	5.68
1969-70	126.36	94.94	76.90	93.84	6.08
(ii) Tamil Nadu					
1965-66	4.72	4.19	3.19	6.31	6.76
1966-67	4.81	4.24	3.93	7.17	8.17
1967-68	4.91	4.17	4.05	6.28	8.25
1968-69	4.96	4.02	4.10	5.77	8.27
1969-70	5.34	4.01	4.53	5.53	8.48
(iii) Karnataka					
1965-66	1.37	1.21	0.38	0.75	2.77
1966-67	1.39	1.22	0.40	0.73	2.88
1967-68	1.39	1.18	0.43	0.67	3.09
1968-69	1.37	1.11	0.47	0.66	3.43
1969-70	1.39	1.04	0.52	0.63	3.74
(iv) all-India					
1965-66	112.70	..	50.53	..	4.48
1966-67	113.50	..	54.82	..	4.83
1967-68	117.70	..	64.47	..	5.48
1968-69	123.30	..	71.05	..	5.76
1969-70	133.10	..	81.95	..	6.16

APPENDIX 24.2
Cashewnut

(Paragraphs 24.3.2 and 24.3.8)

Statement I—Total Availability of Raw Nuts and Export of Cashew Kernel

(thousand tonnes)

Year	Production of raw nuts (a)	Imports of raw nuts (b)	Total availability of raw nuts	Kernel (22% recovery)	Export (d)	
					actual	% of total availability of Kernels
1963-64 . .	144	157	301	66	51	77
1964-65 . .	154	197	351	77	56	73
1965-66 . .	159	161	320	70	51	73
1966-67 . .	167	141(c)	308	68	50	73
1967-68 . .	176	168	344	76	51	67
1968-69 . .	186	195	381	84	64	76
1969-70 . .	197	163	360	79	61	77

Source: (a) Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi.

(b) Monthly Statistics of Foreign Trade of India (Imports), Vol. II, March 1964 to March 1970.

(c) Monthly Statistics of Foreign Trade of India (Imports), Vol. II, May 1966 and March 1967, March 1968, March 1969 and March 1970.

(d) Monthly Statistics of Foreign Trade of India (Exports), Vol. I, March 1964, March 1965, March 1966, April and May 1966 and March 1967, March 1968, March 1969 and March 1970.

(Paragraph 24.3.2)

Statement II—Exports of Cashew Kernel from Selected Countries[1]

(thousand tonnes)

Year	India	Mozambique	Tanzania	Kenya	Brazil	World total
1965 . .	53.8	4.1	Neg.	0.2	0.7	58.8
	(91.5)	(7.0)	Neg.	(0.3)	(1.2)	(100.0)
1966 . .	48.6	5.8	0.6	0.1	1.8	57.0
	(85.3)	(10.2)	(1.1)	(0.2)	(3.2)	(100.0)
1967 . .	52.3	8.1	1.4	0.2	1.5	63.4
	(82.4)	(12.7)	(2.2)	(0.3)	(2.4)	(100.0)
1968 . .	60.5	10.4	1.3	0.2	3.3	75.7
	(79.9)	(13.7)	(1.7)	(0.3)	(4.4)	(100.0)
1969 . .	62.7	12.8	2.4	0.2	4.6	82.6
	(75.9)	(15.5)	(2.9)	(0.2)	(5.5)	(100.0)

1 Information furnished by the Cashew Export Promotion Council, Ernakulam (Kerala).

Note :—Figures in the brackets indicate the percentage to the total exports.

APPENDIX 24.2 (Concld.)

(Paragraph 24.3.6)

Statement III—Statewise Area and Production of Cashew (raw nuts)[1].

area = thousand ha
production = thousand tonnes
yield = q/ha

State	1968-69			1973-74		
	area	production	yield	area	production	yield
Tamil Nadu .	82.9	9.8	1.18	102.7	12.9	1.26
Kerala . .	69.4	67.4	9.71	75.6	80.1	10.59
Karnataka .	44.8	12.1	2.70	57.8	18.8	3.25
Goa . .	21.1	3.5	1.66	29.7	5.4	1.82
Andhra Pradesh	17.9	10.8	6.03	19.0	11.8	6.21
Maharashtra .	15.7	4.8	3.06	58.6	6.8	1.16
Orissa . .	6.9	1.0	1.45	14.5	1.7	1.17
West Bengal .	2.7	1.5	5.55	2.7	1.8	6.67
other States .	2.9	0.4	1.38	3.4	0.7	2.06
total .	264.3	111.3	4.21	364.0	140.0	3.85

1 Information furnished by Directorate of Cashewnut Development, Cochin.

APPENDIX 24.3

Coconut

(Paragraph 24.5.1)

Statement I—Current Utilization of Coconut as Oil and in the form of Kernels (fresh or dried as copra)

present production of coconut oil	30,000 tonnes
copra needed at 50% recovery	60,000 tonnes
copra imported annually in the country (1967-68—1971-72) .	15,000 tonnes
copra of indigenous production used for extracting oil . .	45,000 tonnes
imported copra in terms of nuts @ 5000 nuts per tonne of copra (a)	75 million
copra of indigenous production in terms of nuts @ 7000 nuts per tonne of copra(a) utilized in oil extraction. . .	315 million
production of nuts in the country (1969-70—1971-72) . .	6,000 million
availability of nuts within the country for uses other than oil (i.e. as tender nuts) or as copra or dry nuts in shell .	5,685 million
percentage utilization of indigenous production of nuts for uses other than oil.	94.75 or 95

(a) Calculations done on the basis of the Indian Central Coconut Committee Monograph on Coconut, p. 318, 1957.

APPENDIX 24.3 (Contd.)

(Paragraph 24.5.1)

Statement II—Statewise Area and Production of Coconut[1] (1969-70 to 1971-72)

area=thousand ha
production=million nuts
yield=nuts/ha

State	Area		Production		Yield
	actual	% of all India	actual	% of all India	
Kerala	719.1	68.3	3997.3	66.5	5559
Karnataka . . .	130.0	12.4	659.9	11.0	5076
Tamil Nadu . . .	102.3	9.7	930.4	15.5	9095
Andhra Pradesh . .	37.2	3.5	157.8	2.6	4242
Goa, Daman & Diu .	19.7	1.9	70.0	1.2	3553
Orissa	10.5	1.0	39.0	0.6	3714
Maharashtra . . .	9.5	0.9	46.0	0.8	4842
Andaman & Nicobar Islands	8.7	0.8	37.8	0.6	4345
West Bengal . . .	6.7	0.6	22.0	0.4	3284
Assam	3.8	0.4	11.1	0.2	2921
Lakshadweep . . .	2.8	0.3	19.7	0.3	7036
Pondicherry . . .	1.6	0.2	15.6	0.3	9750
Tripura	0.4	neg.	0.5	neg.	1250
all-India	1052.3	100.0	6007.1	100.0	5709

1 Nov., 1972, Estimates of Area and Production of Principal Crops in India, 1971-72 ; DES.

APPENDIX 24.4

(Paragraph 24.9.1)

Targets of Area for 2000 AD—All Plantation Crops

(Mha)

	Area		Reference	
	present	targeted	appendix	paragraph
tea	0.35	0.45	..	24.1.2
coffee	0.14	0.20	..	24.1.3 24.1.6
cardamom	0.076	0.08	..	24.1.7
pepper	0.12	0.12	..	24.1.8
rubber	0.20	0.38	24.1 Statement II	24.2.12
cashewnut	0.22	0.35	24.2 Statement III	24.3.8
arecanut	0.17	0.17	..	24.4.8 24.4.9
coconut	1.05	1.05	..	24.5.5
oil palm	..	0.025	..	24.6.4
cacao	0.001	0.015	..	24.8.3
total	2.327	2.840		

25

FODDER CROPS

1 INTRODUCTION

25.1.1 India possesses an enormous livestock population. According to Livestock Census 1972 there were 236.8 million cattle and buffaloes, 108.4 million sheep and goats, 6.5 million pigs and 3.3 million other livestock. The vast majority of cattle and buffaloes in India are maintained on the agricultural byproducts which consist of roughages of low nutritive value. Concentrates are fed to milch and draught animals at work only if the farmer can afford to purchase the same. By and large, the feeding of green fodder as a component of daily ration is not practised except in the Government farms and established dairy farms. While the growth of animal population is almost unrestricted the available feed resources for these animals have not kept pace with the increase in their number. According to one estimate[1], the present production of milk can be achieved from about one-third of the cattle population in the country if these are fed properly.

25.1.2 For the allround development of animal industry, breeding, feeding and health cover should receive adequate attention. Feeding and nutritional requirements of the animals have been grossly neglected in the past and even now feed and fodder development programmes are receiving comparatively little attention. It is commonly known that the improved breeds of livestock unless fed properly will be unable to portray their genetic potentiality fully. Improved breeding and health cover are no substitute for proper feeding. The Famine Enquiry Commission[2] rightly observed :

> "Feeding is of crucial importance, for no lasting improvement can be brought about by breeding alone, since improved breeds deteriorate rapidly if not fed adequately. The vast majority of Indian cattle are grossly underfed".

1 1959. India's Food Crisis and steps to meet it. Report by the Agricultural Production Team sponsored by the Ford Foundation.

2 1945. Final Report. The Famine Enquiry Commission.

The country has embarked on a massive cross-breeding programme to enhance production of milk and other livestock products. Increasing attention is also being paid for improved animal health cover. The most crucial input, that is, adequate provision for balanced nutrition as said earlier, has been neglected so far.

25.1.3 Admittedly, the huge number of bovine population is a severe strain on the country's limited feed and fodder resources and an attempt must be made to restrict and even reduce this population. The problem of excessive cattle population and ways and means of tackling it were discussed in the past at various forums [1] & [2]. This subject has been dealt with in detail in Chapters 28, 29 and 34 on Cattle and Buffaloes, Dairy Development and Livestock Feeding respectively.

25.1.4 The available feed resources, limited as they are, must be distributed appropriately and in such a manner that these are put to best use for increasing the production of milk, meat, wool, eggs, etc. The cost of feeding animals constitutes more than 60 per cent of that of milk production. Milk is produced economically when good quality forages make up the greater part of the ration and are grown by the farmer himself. Cultivated fodders and pastures of high quality are usually the cheapest sources of feed nutrients required by the dairy animals for growth, maintenance and milk production.

25.1.5 The requirements and availability of feed and fodder for the country's livestock population have been dealt with in detail in Chapter 34 on Livestock Feeding. It has been shown that by 2000 AD the total requirement of green fodder will be of the order of 595 million tonnes besides that obtained from grazing. In Chapter 34 on Livestock Feeding we have indicated that 16.5 million hectares constituting 8.3 per cent of the total cropped area may be available for fodder crops as against the present area of 6.91 million hectares. In areas covered by intensive cattle development programmes/milksheds, it may become necessary to bring even 33 per cent of irrigated land under fodder cultivation. We fully realise the importance of extending the area under fodder crops and, therefore, in the plan of allocations of lands for various crops, the area under fodder crops has been increased from 4.2 per cent to 8.3 per cent. The increase of more than 100 per cent in the area under fodder is not going to be easy but this is essential if the country's animal industry is to attain its proper stature.

25.1.6 In order to cover the area required for fodder production as well as augment production per unit area and time, concrete steps will

1 1957. Report, Committee of the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry.

2 1959. FAO meeting on Dairy Problems in Asia and the Far East—New Delhi.

have to be taken in three directions. There should be (a) strong research base for undertaking effective programmes for evolution of high yielding, nutritionally superior and disease resistant varieties and standardisation of packages of practices as applicable to different agroclimatic regions, (b) massive farmer-oriented extension programmes on fodder crops both for production as well as conservation, and (c) efficient arrangements for production—from the breeder to the certified seed stage—distribution and timely supply of seeds of high yielding varieties to farmers.

25.1.7 In this chapter we discuss these topics with particular reference to the areas which need immediate and special attention. It may be emphasised that green fodder production is the most important single factor on which will depend the success of the animal husbandry programmes and the prospects of achieving the targets set forth for production of different animal products. Breeding and health cover aspects have received increasing attention in the Five Year Plans but scientific feeding of livestock has been neglected. Even now the financial allocation made available for development of feeds and fodder resources is extremely meagre in proportion to the need. In the State sector only Rs. 8.22 crores have been provided for feed and fodder development programmes during the Fifth Five Year Plan, which constitutes 4.7 per cent of the total allocation under animal husbandry development[1]. It is unlikely that the required impact can be achieved with such meagre allocation of resources particularly when the States have neither the basic infrastructure for undertaking an effective development programme nor are there proper arrangements for production and distribution of seeds of fodder crops. We are strongly of the view that since there is lack of proper awakening about the essentiality of adequate fodder production in the country, radical changes will have to be brought about in the entire set up as well as working arrangements insofar as fodder development is concerned.

2 REVIEW

Research Aspects

25.2.1 Sporadic efforts had been made in the past in different parts of the country to (a) increase the yield of cultivated fodders, (b) to introduce fodder legumes in the existing crop rotations, (c) to improve

1 Information from Feed and Fodder Unit of the Ministry of Agriculture, Department of Agriculture, New Delhi.

the production of grasslands/community grazing lands and forest lands open to grazing, and (d) to provide and improve the facilities to conduct research on various aspects of fodder production including evolution of improved varieties. In the pre-Independence period, various commissions and experts 1-5 had emphasised the need for research and development of feed and fodder in order to augment animal production. One of the aspects emphasised by them was the introduction of mixed farming in the agricultural economy of the country. Between 1941 and 1946, the Indian Council of Agricultural Research (ICAR) launched a scheme to investigate the feasibility of introduction of mixed farming in 4 provinces of undivided India[6]. The results of these investigations showed that mixed farming units were more remunerative than the control. Details of these experiments as well as the importance of mixed farming have been specifically discussed in Chapter 33 on Mixed Farming.

25.2.2 Studies on grasslands and fodder were undertaken by the erstwhile Bombay Presidency as early as the close of the previous century and were enlarged around 1912 by Burns and his associates[7]. The work conducted by the latter is perhaps the earliest recorded on grasslands and their management. Sir William Jenkins, Agricultural Commissioner of Bombay, obtained a large collection of grasses and legumes in 1945 for testing with regard to their suitability in different areas of the province. A scheme[8] was initiated in 1948 for improvement of grasses and leguminous fodders in Bombay State with the following objectives :

(i) Introduction and acclimatisation of superior forage grasses and legumes collected from both indigenous and exotic sources ;
(ii) Improvement of indigenous grasses and legumes ;
(iii) Method of establishment of swards; and
(iv) Balancing pasture herbage in desirable proportions of grasses and legumes with a view to improving the feeding value.

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1 1928. Report, Royal Commission on Agriculture in India.

2 1945. Final Report, The Famine Enquiry Commission.

3 Wright, Norman C. 1937. *Report on the Development of the Cattle and Dairy Industries in India.*

4 Papperal, R.A. 1945. The Dairy Industry of India, Report on an investigation with Recommendations.

5 Kay, H.D. 1946. Report on Dairy Research, Dairy Education and Dairy Development in India.

6 Finney, D.J. and Panikar, M.P. 1953. Experimental Tests of Mixed Farming in India. Indian J. Agric. Sci., Vol. 23 (4) ; 269-281.

7 Burns, W. 1915. The Improvement of Natural Grasslands in India, Agric. J. India, Vol. 10: 288-293.

8 Whyte, R.O., 1964. Grassland and Fodder Resources in India, New Delhi. Scientific Monograph No. 22, Indian Council of Agricultural Research.

Useful derivates of napier-bajra crosses were studied for the first time in Bombay State.

25.2.3 Work on grasses and legumes in the erstwhile Madras Presidency was initiated around 1904. From 1930 onwards intensive work was undertaken mainly at the Agricultural College and Research Institute, Coimbatore, with financial help from the ICAR. Research work was further intensified since 1950 by including observations on drought tolerance etc., in respect of many indigenous species.

25.2.4 The erstwhile Punjab Province took a leading part in the improvement of cultivated fodders. Work on fodder crops was started by the Department of Agriculture with the appointment of a Fodder Specialist in 1925. The Fodder Research Station was first started at Lyalpur and functioned there from 1925 to 1934 when it was shifted to Sirsa. The Research Station at Sirsa made significant contribution by evolving new varieties of fodder crops like lucerne (*Medicago sativa*), *Berseem* (*Trifolium alexandrinum*), cowpea (*Vigna sinensis*), *jowar* (*Sorghum vulgare*), teosinte (*Euclaena mexicana*), oats (*Avena sativa*), *senji* (*Melilotus parviflora*), *metha* (*Trigonella*), *guar* (*Cyamopsis tetragonoloba*), *moth* (*Phaseolus aconitifolius*), etc. Some of these varieties are still in use. This Station conducted research on hill grasses at its sub-station at Palampur, Himachal Pradesh.

25.2.5 Work on breeding and agronomic aspects of fodder and pasture species was initiated at the Indian Agricultural Research Institute (IARI), New Delhi in 1953. The ICAR sponsored a rapid reconnaissance survey on grasslands in India and on the basis of the information available from the survey, studies were intensified on certain selected species. The napier-*bajra* hybrid (Pusa Giant), Pusa Giant *berseem* (tetraploid) and Pusa Giant *anjan* are significant contributions of this Institute.

25.2.6 Research and development of fodder crops received further impetus with the establishment of the National Dairy Research Institute (NDRI), Karnal in 1955 and the Central Arid Zone Research Institute (CAZRI) at Jodhpur in 1959. The NDRI, Karnal, laid particular emphasis on popularisation of improved fodders and grasses for feeding dairy cattle. Conservation of fodders, particularly in the form of silage, received good attention at the NDRI. CAZRI initiated work on grassland development and management. Large scale studies were undertaken on drought resistant grasses and legumes and pilot projects undertaken on establishment and management of improved grasslands. The work on fodder and grassland development also received attention in some of the States.

25.2.7 Government of India obtained the services of a FAO expert in early fifties to make a thorough study of the problems relating to

grassland and fodder Research/Development in India. The expert *inter alia* recommended the establishment of a Central Grassland and Fodder Research Institute. The Indian Grassland and Fodder Research Institute (IGFRI) was set up at Jhansi in 1962 based on the recommendation of the FAO expert. The Institute has the following main objectives :

(i) to carry out research, both of basic and applied nature on grasses, grasslands and fodder crops as related to sustained production of high quality fodder for efficient animal production, maintenance of soil fertility and crop production;

(ii) to evolve high yielding, fertilizer responsive, disease and pest resistant and superior quality forage and fodder crops suited to different agro-climatic regions of the country ;

(iii) to study all aspects of the problems of weeds in cultivated fodder crops and grasslands and evolve economic measures of their control;

(iv) to design and fabricate efficient, low cost, labour saving farm machinery and implements from indigenous materials to meet the diverse needs, with special reference to forage cultivation in small farm holdings;

(v) to collect, coordinate and collate research work on the subject in the country; and

(vi) to disseminate knowledge on the subject through organised training programme and conduct large scale forage demonstrations at national level.

For successful implementation of these objectives through a comprehensive multidisciplinary problem and production-oriented research, the Institute has set up six technical divisions viz., (a) Plant Improvement, (b) Soil Science and Agronomy, (c) Grassland and Management, (d) Plant-Animal relationship, (e) Weed Ecology and Control and (f) Extension and Economics. A division of seed production and technology has also been added in 1975.

25.2.8 In order to provide for a broad-based testing programme under different agroclimatic conditions, a coordinated project on fodder crops was started in 1970. The project has eight main centres and six subcentres representing different agroclimatic regions of the country as mentioned below. The main and subcentres are staffed with research and experimental facilities.

Main Stations

1. Haryana Agricultural University, Hissar
2. Agricultural Research Institute, Ranchi, Bihar

3. Agricultural College, Coimbatore, Tamil Nadu
4. University of Kalyani, West Bengal
5. College of Agriculture, Anand, Gujarat
6. College of Agriculture, Palampur, Himachal Pradesh
7. Indian Agricultural Research Institute, New Delhi
8. Indian Grassland and Forage Research Institute, Jhansi, Uttar Pradesh.

Sub-Stations

1. College of Agriculture, Poona, Maharashtra
2. A. P. Agricultural University, Hyderabad, Andhra Pradesh
3. J. N. Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh
4. College of Agriculture, Jorhat (Assam)
5. CAZRI, Jodhpur (Rajasthan)
6. College of Agriculture, Vellayani, Kerala.

25.2.9 The agricultural universities located in the different States also conduct some research on fodder crops. However, the emphasis and importance placed on fodder crops differ considerably from one university to another. The Haryana Agricultural University has created a separate department on fodder crops at par with other departments. The Punjab Agricultural University has an Economic Botanist (Fodder) in the Department of Plant Breeding. The All-India Coordinated Research Projects on Sorghum, Millets and Dryland Farming have also certain specific programmes for research on fodder crops. Many of the State departments of forests participate in scientific research-cum-development schemes on grasses under forest canopies.

25.2.10 In order to conduct research on temperate and alpine species of grass the Government of Himachal Pradesh created a Section on Agrostology in the Department of Agriculture and established a Regional Station at Simla. At this station work was conducted on the introduction and testing of temperate forage like rye grass, brome grass, orchard grass, *Phalaris tuberosa, Phleum pratense, Festuca pratensis,* white clover, red clover, etc. A large collection of strains of the species mentioned above has been made and tested at Simla, Kulu and Keylong. On the basis of these tests, multiplication of seeds of the most adapted species was undertaken.

25.2.11 With a view to achieving quick transfer of technology particularly in respect of the new high yielding varieties, the Government of India initiated a scheme on the establishment of Regional Stations for Forage Production and Demonstration under different agroclimatic conditions of the country during the Fourth Five Year Plan. These stations were established at Hissar (Haryana), Suratgarh

(Rajasthan), Kalyani (West Bengal), Dhamrod (Gujarat), Alamadhi (Tamil Nadu), Hyderabad (Andhra Pradesh) and Shehama (Jammu and Kashmir). A programme of conducting demonstrations on farmers' fields in collaboration with the State agencies was also initiated. The United Nations Development Programme (UNDP) provided assistance for the establishment of two of these stations (Kalyani and Hissar) during 1969-1971 (Phase I). This assistance is being continued in Phase II from 1975 for a period of four years in the form of provision of equipment, training facilities and some expertise.

25.2.12 From the above, it will be seen that the country has just begun to tackle the problems of fodder and grassland development. But the resources provided for both research and development are far from adequate. Considering the vastness of the country and its agro-climatic diversities, the research work done so far is not sufficient to answer most of the pressing and unsolved questions, particularly in respect of the unirrigated areas and these with low and erratic rainfall. For areas with assured irrigation potential, high yielding photoinsensitive varieties of crops, particularly legumes which can be suitably fitted in the existing crop rotations, provide the answer. Furthermore, whatever improved technology has resulted from the research work already done, it has not percolated to the farmers level. Large scale field trials must be done without delay. The establishment of demonstration centres with UNDP assistance may largely meet this need. Insofar as the grasslands are concerned, the situation is much worse. Little or no efforts have been made towards improvement or protection of the extensive grasslands available in the country. Due to decades of misuse and overgrazing, these grasslands have deteriorated, so much so that in many places the protective grass cover has almost been removed subjecting them to extensive erosion. These aspects have been dealt with in Section 4.

Development Aspects

25.2.13 It is recognised that development of feed and fodders has been neglected in the past and not enough was being done to improve the situation. Fodder production, so essential for livestock development, was not regarded as a definite charge either of the Veterinary Department or of the Agriculture Department. From the Second Five Year Plan, however, the Animal Husbandry Department started paying some attention to fodder and grassland development and feed and fodder development programme was included as part of the key village scheme. The programme envisaged (a) organising production of seeds and planting material of recommended fodder crops, (b) supplying

seeds to farmers/cattle owners at subsidised rates, (c) popularising conservation of seasonal surpluses of fodder through silage and hay making, (d) minimising wastage through use of chaff cutters, (e) undertaking pasture development at State livestock farms, (f) organising pasture development plots in key village blocks, (g) popularising balanced feeding of stock through subsidised supply of concentrate feeds and mineral mixtures, and (h) constituting fodder and grazing committees in the States to periodically review the progress in the implementation of the programme and to bring about coordination in the activities of Agriculture, Animal Husbandry and Forest Departments. However, the infrastructure provided for this multipurpose programme was extremely inadequate and so was the financial allocation.

25.2.14 The programme was enlarged and included as a full-fledged scheme under the Third Five Year Plan with a view to extending these activities from the key village blocks to other areas. Emphasis was *inter alia* laid on the establishment of fodder demonstration-cum-training centres and organising demonstration of cultivation of fodder crops on farmers' fields. Feed and fodder development was included as an integral item of work in the Intensive Cattle Development Projects taken up under the Special Development Programmes during the Third Five Year Plan. Development of grass resources in areas under control of Forest Departments also came to receive some attention and a small programme was included in the forestry sector in the Third Five Year Plan of some States.

25.2.15 Even with the initiation of these programmes there was no attempt to build up a proper fodder development wing in the States or create a worthwhile infrastructure to undertake an aggressive fodder development programme. The result has been that the development efforts failed to yield the desired results. As stated earlier, during the Fourth Five Year Plan the Government of India initiated a scheme for the establishment of regional stations for fodder production and demonstration in the different agroclimatic regions of the country. The intention was to achieve quick transfer of technology and to maintain a close liaison with the research stations on the one hand and the State development agencies on the other. These stations not only produced seeds of the high yielding varieties of fodder crops for distribution to the State agencies for further multiplication but also conducted demonstrations in farmers' fields using the high yielding varieties and improved package of practices. Thus some efforts were made to complement and strengthen the State efforts in this field. However, with the limited resources available at the regional stations it was unlikely that any significant breakthrough could be achieved. It is, therefore, essential that fodder development organisation in the States should

be greatly strengthened.

25.2.16 Anyone interested in fodder development will have to reckon with the fact that the area under fodder crops has not increased to any appreciable extent during the last few decades. This is a rather disturbing trend particularly in view of the fact that a number of important projects have been launched during the past two plan periods for development of animal husbandry. It is, therefore, necessary that all-out efforts should be made to increase the area under fodder crops. We have stated earlier that 16.5 Mha would be available for fodder production. We would like, however, to stress that just increasing the area under fodder will not be enough. More important will be to increase the yield per unit area as well as the quality of fodder through adoption of high yielding and nutritionally improved varieties alongwith a superior package of practices as applicable to these varieties. Of course, it would also be necessary to increase the area by introduction of fodder crops in the existing major crop rotation, multiple cropping along with the use of dual purpose varieties, and raising fodder as companion crops. Additionally maximum conservation of seasonal surpluses of fodder should also be done wherever possible. In order to achieve these objectives the States must organise the necessary infrastructure and provide for a team of properly trained and dedicated specialists to carry the latest research findings to the farming community. High yielding nutritious fodder crops combined with high yielding animals should compete favourably with any food or cash crops[1]. The country's efforts should be directed at present towards achieving this combination.

3 CULTIVATED FODDERS

25.3.1 In order to make livestock development programme successful it is imperative that each State should, as far as practicable, be self-sufficient with regard to the supply of green fodder. Unlike concentrate feeds and dry fodder, green fodder as such cannot be transported over long distances because of among other things, cost and danger of quality deterioration.

25.3.2 In order to augment the fodder resources of a region or State it is necessary to develop high yielding varieties of fodder crops, both legumes and nonlegumes, suited to different agroclimatic conditions along with the packages of practices suitable for these improved varieties. It appears unlikely that under the present agro-socio-economic

1 Studies in Dairy Economics and Statistics (1962-72), Vol. I; 84. Division of Dairy Economics and Statistics, National Dairy Research Institute, Karnal.

conditions farmers other than progressive dairy farmers will set apart any area for growing fodder crops. Small farmers having only a few milch animals do not normally grow fodder crops. The extension services, therefore, have to be greatly strengthened in order to educate the farmers about the desirability and necessity of growing fodders for remunerative livestock enterprise. Simultaneously, vigorous programmes of introduction of fodder crops into cropping systems have to be initiated along with arrangements for supply of seeds of suitable varieties of fodder crops. That fodder crops also respond to special agronomic practices and fertilisers etc. should be brought to the notice of the farmers.

25.3.3 India has a very rich grass flora which when properly exploited can go a long way in meeting the needs of the different agro-climatic regions. In addition, many high yielding types of fodder crops have been introduced in the country during the last half a century. There are a number of potentially high tonnage fodder crops that could be used depending on the needs of the specific region. Among green cereal fodders *jowar* (*Sorghum vulgare*), *bajra* (*Penniseturm typhoides*), maize (*Zea mays*) and oats (*Avena sativa*) art of high quality. Other important gramineous fodders are napier or elephant grass (*Pennisetum purpureum*) and its hybrids with bajra guinea grass (*Penicum maximum*), rhodes grass (*Chloris gayana*), sudan grass (*Sorghum vulgare* var. *sudanensis*), teosinte (*Euchleana mexicana*), thin napier (*Pennisetum polystachyon*), blue panic (*Panicum antidotale*), para grass (*Brachiaria mutica*), *dinanath grass* (*P. pedicellatum*), which are already under use in many areas and are quite popular. Among legumes, *berseem* (*Trifolium alexandrinum*), and lucerne (*Medicago sativa*) may be regarded as the most productive and popular rabi fodders. Other legume fodders which could be grown as pure crop or in combination with other fodders/grasses are cowpea (*Vigna sinensis*), *guara* (*Cyamposis tetragonoloba*), *shaftal* (*Trifolium resupinatum*), *senji* (*Melilotus parviflora*), *valvet bean* (*Mucuna cochinchinensis*), stylo (*Stylosanthis guyanensis*) etc. A good fodder should be palatable, digestible and devoid of any harmful components. It should be high yielding, quick growing and have a quick regeneration capacity where such a characteristic is desirable. Above all, the fodder should have high nutritive value.

25.3.4 In conducting researches on forages there are some aspects which need to be tackled on priority basis. Some of these points are discussed in the succeeding paragraphs.

Breeding Aspects

25.3.5 During the last decade and a half, researches have been

conducted in different parts of the country on the introduction and selection of high yielding varieties of different fodder crops. There are some qualities, however, which need to be introduced through breeding work, if necessary, using germ-plasm available outside the country.

25.3.6 Varieties so far evolved have mainly been selected on the basis of their fodder attributes irrespective of their seed production qualities. Consequently, most of the existing high yielding fodder varieties are shy seeders. But some of the varieties like Cluster Bean F.S. 277 and Cowpea HFC 41 developed by Haryana Agricultural University have both the qualities of high fodder and grain yields. Efforts should be made in future breeding work to incorporate these desirable two-fold qualities.

25.3.7 In research programmes, emphasis has been on the tonnage rather than the nutritive value, palatability, digestibility, etc. Efforts, therefore, have to be made to combine high yield with high nutritive quality. Technically speaking, the aim should be to obtain the highest amount of digestible crude protein/total digestible nutrients (DCP/TDN) per unit area per unit time.

25.3.8 The present day average yields of fodder crops are still very low. High yielding varieties as well as improved production technology should be fully utilised to raise the yield levels. Yield levels of, say, 50 to 70 tonnes per ha for all seasonal fodders, 100 to 150 tonnes or more for some special fodder crops like *berseem*, lucerne and interspecific hybrids like napier-bajra, should not be difficult to achieve if appropriate agricultural practices together with adequate inputs are assured. From all India trials, we learn that yields of some of the hybrids range between 200 and 300 tonnes per ha. These may appear to be exceptions in the background of low average yields but they do indicate that there is scope for greatly improving the yield performances of fodder crops. It is necessary that new hybrids should be tested for optimum performance under different agro-climatic conditions, particular attention being paid to those with good growth during the winter months of northern India.

25.3.9 The use of forages which are nutritionally adequate may be restricted because of the presence of some pharmacologically active and undesirable components. Some such examples are cited below :

Lucerne	—Oestrogens & saponin
Senji (Melilotus sp)	—Coumarin
Sorghum	—Hydrocyanic acid, tannins and nitrate nitrogen
Bajra Dinanath grass and napier hybrids	—Oxalic acid
Oats	—Nitrate nitrogen

The wide genetic variability in crops with regard to toxin and their contents has to be taken advantage of to breed toxin-free varieties.

25.3.10 We have indicated earlier the need for fodder varieties suitable under rainfed conditions and for low rainfall areas. High yielding varieties suitable under irrigated conditions are known but none so far for rainfed areas. We recommend that immediate attention should be paid to evolve grasses and legumes suitably for rainfed conditions. Special attempts should be made to develop dual purpose legumes, i.e., yielding grain as well as fodder, so that even farmers having no spare land can use them in crop rotation.

25.3.11 In general, there are two scarcity periods in a year, viz., May-June and October-November, when crops are being harvested and preparations made for the next crop. Of these two periods, the former is too rigorous for growth of fodder crops owing to greater scarcity of water. In the circumstances, it is expeditious to breed multicut varieties which can overlap these periods or evolve varieties with fast rates of growth and adapted to the prevailing conditions.

25.3.12 Varieties which have been specially developed for fodder purposes but are found to be susceptible to diseases and pests have received very little attention so far. It is necessary to evolve varieties resistant to the prevalent diseases and pests. Effective and timely control measures against pests and diseases are necessary in case of fodder crops as well.

25.3.13 Very little work has been done in the country so far on introduction or production of root crops like swede, turnip, mangold, beet, and carrot for fodder. Some of these root crops produce high tonnage within a short period and can be fitted in the existing crop rotations. One of the reasons for insufficient work on these crops is perhaps their indifferent seed production for which special agro-climatic conditions are required. Seeds of most of these crops can, however, be produced in the hilly areas of northern India where conditions are congenial. All these aspects need to be looked into urgently. For areas with insufficient rainfall and irrigation facilities choumoellier (*Brassica oleracea var. acephala*) can be grown instead of *berseem*. This crop, we understand, was introduced by the Agricultural Research Institute, Ranchi, Bihar many years ago and proved to be highly promising. Further development work, however, was not carried out. Other crops like *Vicia* sp. etc. can also be introduced. Research work on all such species which hold promise under low rainfall condition should be intensified.

25.3.14 In view of diverse agroclimatic conditions and hence varied requirements of different regions, it is imperative to acquire and build up extensive collection of germplasm of suitable grass and

legume species. Up till now no suitable legume has been identified for grasslands particularly of the drier regions. Cowpea is by far the most popular summer fodder which is grown in combination with other crops like maize, *jowar* and hybrid napier under irrigated conditions. It has, however, one defect ; it cannot tolerate shade. Efforts should, therefore, be made to locate a high yielding quick growing shade tolerant legume which can combine well with cultivated fodders. Similarly, quick growing photoinsensitive varieties are required for use both under irrigated and rainfed conditions to fit into the major crop rotations in different parts of the country. Research work on all these aspects has to be intensified.

25.3.15 In order to build up the required germplasm collection in the country, a few experts may be deputed to select suitable cultivars from those of the tropical/subtropical countries which have promising grasses and legumes. Of these, Argentina, Brazil, Central and East Africa may be particularly mentioned. Close scientific collaboration and mutual exchange of material should be maintained with Australia, United Kingdom, USA etc. which have already built up a rich collection of germplasm of grasses and legumes.

Production Technology

25.3.16 Apart from the evolution of genetically superior varieties suitable for agroclimatic zones, varied growing seasons etc. the management of the crop is the most important factor in realising the optimum yields. The whole gamut of agronomic manipulations which ensure good management are discussed below.

25.3.17 Few fodder crops have good keeping quality except when special techniques of preservation are employed. It is, therefore, important to time their planting in accordance with their demand period. Few of them, again, have a reasonable spread of time during which the harvested fodder is most palatable. This makes it important that the harvesting is done during that period. The chemical constituents of fodders vary greatly according to the stage of growth. From the nutritional stand-point it would, therefore, be desirable to harvest the fodder when their quality and quantity are optimally matched. With the maturity of a forage crop, its fibre content and total dry matter increase and since digestibility and fibre content of a fodder crop are negatively correlated, a compromise is to be made between the dry matter content and digestibility in order to fix the right stage of harvesting. The optimum sowing as well as harvesting schedules will vary in the different agroclimatic regions and, therefore, such schedules for particular crops are required to be

determined experimentally for each region.

25.3.18 The use of fertilizer and nutrient element for forage crops is as essential as for other crops, particularly when intensive fodder growing is intended. Otherwise, not only will the yield of the forage crop be low, but the soil will also get depleted of its nutrients. Broad ranges of yield potential of fodder crops have been indicated earlier. However, such yields cannot be realised without adequate input of high quality seed, fertilizers and irrigation. In most cases, nitrogen for nonleguminous and phosphorus for the leguminous crops result in increased production. However, in specific areas the requirements may vary. We are informed that at Anand, Gujarat, potassium was found to be more essential than phosphorus for increased yield of lucerne ; in Rajasthan, nitrogen application was important for even a leguminous crop like cluster bean ; for nonleguminous crops also phosphorus may prove to be important, e.g., in Jabalpur, where P_2O_5 at 60 kg/ha was essential along with N 150 to 200 kg/ha for *dinanath* grass. The role of minor elements in enhancing green and dry matter production has also been effectively demonstrated. For example, some Hissar results prove the need of zinc for better performance of sorghum. Optimum results from fertilization alone cannot be obtained without a composite supporting schedule of tillage operations, irrigation and plant protection measures. As already stated above all these measures are being neglected. Therefore, it is not enough to formulate schedules of agronomic and plant protection but it is also essential to put them into practice.

25.3.19 One of the important aspects on which more work should be carried out is on the possibilities of introducing fodder crops in rotation with other field crops or as mixed crop with widely spaced field crops. There are possibilities of taking a quick maturing fodder crop before or after the main crop. Such possibilities are immense especially in irrigated areas and in those areas where the rainfall is spread over a period of about 6—8 months. The tendency now is to take some other food/cash crops. Even in the multiple cropping studies which are being carried out in large numbers, the fodder component is negligible. Fodder crops have a number of advantages. As most grasses have extensive fibrous root systems, they improve the soil structure and as such serve a useful purpose in crop rotations. They are usually of short duration and will rarely prove to be complete failures as most of them could be harvested for fodder at any stage. In regions having good pre-monsoon showers, it is possible to take a fodder crop before or after the main crop. In some areas of Karnataka, it has been possible to introduce a maize—*chowli, jowar* or *avare* as fodder crop before *ragi* by taking advantage of the April,

May and June showers. Sown in August *ragi* can mature with the September-October rains. Such possibilities exist in a number of other regions also and this should be exploited in full to bring about increase in the production of fodder.

25.3.20 Possibilities of growing fodder crops, particularly legumes, in rotation with food and cash crops have not been fully explored. Studies carried out as early as 1926 at Dharwar have shown that rainfed kharif *jowar* yields double the quantity of grain after rainfed lucerne crop in the previous year. Studies on fodder crops are usually carried out independently, but never as part of the cropping system. More intensive studies are required to be carried out to assess the value of each fodder crop as part of the cropping system both under rainfed as well as irrigated conditions.

25.3.21 Very few studies have been carried out so far to explore the possibility of growing fodder crops as mixed crops with other broadly spaced crops. One of the studies carried out at the Sugarcane Research Station, Padegaon, indicates the possibility of taking lucerne as a mixed crop with sugarcane. As much as 25,000 kg of green fodder per hectare was harvested from such a mixed crop. It is possible to grow some of the fodder legumes with cotton, maize, and other similar broadly spaced crops. Similarly, efforts have to be made to grow grasses and legumes singly or in mixtures in plantation crop, viz., coconut, areca-nut, etc.

25.3.22 In general, it can be said that agronomy of fodder crops, especially with regard to their place in cropping systems, is still to be clearly understood. Appropriate cropping systems have to be developed in conformity with the conditions of the different regions of the country. Due to high pressure on land it would be difficult to set aside a large proportion of cultivated land exclusively for fodder production. Attempts have, therefore, to be made to fit them judiciously into cropping systems keeping in view the overall agronomic and economic objective, namely, that of getting the maximum return per unit of land, at the same time maintaining the soil fertility at high level. We recommend that intensive studies should be undertaken on all aspects of growing fodder crops in mixtures with other crops and the economics of such practices worked out for each region.

25.3.23 There is dearth of germplasm material in the case of forage legumes. This, coupled with the lack of (a) suitable techniques of evaluation in mixed stands, (b) breeding procedures due to the peculiarities in the modes of their reproduction, (c) knowledge of evaluation for dry matter yields and nutritive quality in terms of total digestible nutrients, and (d) knowledge of factors influencing seed setting and seed production in forage legumes has proved to be a

serious handicap to forage legume breeders in this country. Furthermore, efforts of the latter to develop varieties were largely restricted to single plant selections and that too in such self-fertilised legumes as cowpea, *guar, Phaseolus* species, *Dolichos lablab, Mucuna* species etc. The varieties thus developed for the most part did not involve hybridization and selection for forage characters in segregating populations. Although IGFRI as well as some of the agricultural universities have initiated some work in order to remove these handicaps, there is need to tackle these problems in a more concerted manner and for this purpose the breeding and agronomic programmes being implemented in the country have to be suitably geared.

25.3.24 Seed production aspects of some of the forage legumes such as lucerne and *berseem* need special attention. Lucerne has been reported in most of the regions to be a shy seeder. Seed production of this crop may be dependent on a number of factors including presence of the right kind of bees for tripping the flowers. Lucerne is grown under a wide variety of climatic and soil conditions both in the plains and on the hills. We recommend that special studies be undertaken by IGFRI and other central institutes and agricultural universities working on forage crops to study this aspect and to find a solution to the seed setting problems of lucerne, *berseem* as well as other crosspollinated legumes and grasses grown under different agroclimatic conditions. The important role played by the honey bees in fertilisation and seed setting particularly in crops like *berseem,* lucerne has been discussed in Chapter 27 on Apiculture.

25.3.25 The sorghums or *jowars* of different kinds are the most commonly grown in the country as rainfed as well as irrigated crops. When intended solely as fodder crops, thick sowing is resorted to. The sorghums give only one crop with each sowing though a small crop of ratoon or stubble crop under irrigation can be harvested. There appears to be considerable scope in developing suitable varieties which will be amenable to multi-harvesting. One of the studies carried out at Dharwar indicates that rabi *jowar* variety can be sown in kharif, as after harvesting it as fodder, it can be allowed to mature and yield good grain in rabi season. Detailed studies are required to be carried out to develop suitable *jowar* varieties which can give one or two cuttings of fodder and also yield good quantity of grain. Studies in this direction are under way at International Crop Research Institute for Semi Arid Tropics (ICRISAT) in Hyderabad and a number of dry farming research stations. However, the present indications are that the grain yields go down considerably when the crop is harvested one or more times for fodder purposes. It is, therefore, necessary to develop suitable dual purpose varieties.

4 GRASSLANDS

25.4.1 According to ecologists[1,2], grasslands do not occur as a climatic climax in India. In other words, these grasslands represent an interim stage (Preclimax), in the succession and some of them may be relatively very stable under the influence of various biotic factors such as fire, grazing etc.

Types of Grass Cover in India

25.4.2 The first ever attempt to study the existing types of grasslands in India was made during the rapid reconnaissance survey which the ICAR initiated in 1953. The results of the survey have been documented in the monograph entitled "The Grass Cover of India". The main objective of the survey was to study the various grassland communities as they occur in the varied climatic and sociological conditions in India and recording the changes in relation to the ecological factors of the environment, whether natural or introduced by man. As a result of the survey, five major types of cover with their corresponding lower stages in the succession, were recognised. The types of grass cover and the distribution of each are given below :

Type of grass cover	Distribution
1. *Sehima-Dichanthium* type	Whole of peninsular India, the Chhota Nagpur plateau and the Aravalli range comprising the States of Gujarat, Maharashtra, Madhya Pradesh, Orissa, Andhra Pradesh, Kerala, Tamil Nadu, Karnataka, South Bihar and South West Bengal and southern hilly portion of Uttar Pradesh and Rajasthan.
2. *Dichanthium-Cenchrus-Lasiurus* type	Sub-tropical arid and semi-arid region comprising the northern portion of Gujarat, whole of Rajasthan (excluding the Aravalli range in the south), western Uttar Pradesh, Delhi and Punjab.
3. *Phragmitis-Saccharum-Imperata* type	Whole of Gangetic plain; the Brahmaputra valley comprising States of Manipur, Assam, Tripura, West Bengal, Bihar, Uttar Pradesh, Delhi and Punjab.
4. *Themeda-Arundinella* type	The entire northern and northwestern montane tract in the States of Manipur, Assam, West Bengal, Uttar Pradesh, Punjab, Himachal Pradesh and Jammu & Kashmir.
5. Temperate-Alpine type	High hills of the northern mountain belt comprising Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, West Bengal and Assam.

1 Champion, H.G. 1936. A Preliminary Survey of the Forest Types of India and Burma. Indian For. Rec. N.S., Silvicult.

2 Bor, N.L. 1942. Ecology ; Theory and Practice, Proceedings 29th Indian Sci. Cong., Baroda, Part : II 145-179.

25.4.3 Although the broad cover types have been described along with the species existing under the different biotic conditions, it may be necessary to undertake further intensive work in areas where grassland development is to be undertaken. For the temperate and alpine cover, the number of sites examined in the survey was limited and it is, therefore, necessary to undertake intensive studies both in the eastern and western Himalayas.

25.4.4 The present deteriorated state of the grasslands in India is well known. This is the result of decades of overgrazing and neglect. In many areas the protective cover has been almost completely removed leading ultimately to extensive erosion. In other areas the productivity of grasslands has deteriorated due to the elimination of the perennial types and their replacement by inferior annual species.

25.4.5 Although accurate estimates of area under the existing grasslands in the different States are not available the area classified as permanent pasture and other grazing land covers 13.3 Mha.[1] In addition, there are 16.1 Mha under culturable wastes. Out of the 66.0 Mha classified under forest no accurate estimates are available as to the area which may be termed as grassland or from which grass could be collected. It is estimated[2], however, that the total forest area open to grazing in tropical India is of the order of 36.13 Mha.

25.4.6 As we have indicated earlier no attempt has so far been made to protect and improve the extensive grasslands available in many States. Isolated examples of increased productivity that can be achieved through ameliorative measures are available in some of the Government farms, particularly the military farms. Trials conducted by IGFRI[3], Jhansi and CAZRI[4], Jodhpur have also shown that remarkable improvement in yield can be achieved by adoption of improved management techniques. Once the principal biotic interference, viz., the grazing animal, is removed, the grasslands regenerate very fast and the production increases 2 to 4 fold within a few years. Protection of grassland is, however, not any easy proposition. The problem of overgrazing throughout the country is so acute that the possibilities of improvement of grassland have generally been considered merely as a theoretical exercise. It can be safely said, however, that the grasslands normally carry many times the number of animals than they are capable of. It would, therefore, be necessary not only to limit the stocking rate but also undertake other

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1 Classification of Area & Irrigated Area, Statewise (1971-72), New Delhi. Directorate of Economics & Statistics, Ministry of Agriculture.

2 1970. Indian Forest Statistics 1960-61 to 1962-63, New Delhi. Directorate of Economics and Statistics, Ministry of Agriculture & Irrigation.

3 Magoon, M.L., & Dabadghao, P.N. 1973. How to achieve potential grassland production, Indian Farming, Vol. 23(5) : 15.

4 Ahuja L.D. 1973. Forage Production (with special reference to Arid Zone). Jodhpur, Central Arid Zone Research Institute.

measures for improvement of the grasslands. The problem of the increasing number of largely useless animals has already been dealt with earlier. This is intricately linked with the development of all fodder resources including the development of grasslands. Unless the number of animals is restricted and a system of controlled grazing adopted, it would not be possible to bring about any improvement in grassland productivity.

25.4.7 The northern hilly tracts of India deserve careful and immediate attention not only because they have many of the important watersheds but also because they constitute highly potential tract for development of livestock industry. The watersheds in the hilly tracts present certain peculiar problems of soil conservation, overgrazing and erosion. The animal industry in these tracts will continue to depend mainly on the grasslands and grazing lands inside and outside forests, as cultivable area is limited. It is, therefore, imperative that immediate steps are taken for development of grazing resources in a manner consistent with the requirements of watershed protection as well as optimum production of forage.

25.4.8 In view of the fact that no consistent effort has been made in the past for grassland development, we indicate in the following paragraphs some aspects of a rational and scientific approach to problems of grassland improvement under different agroclimatic conditions.

Fundamental Makeup of Grasslands

25.4.9 A knowledge of the fundamental makeup of the grasslands of a region is essential pre-requisite for formulating any plan for their systematic development and management. The first necessary step is to determine the four condition classes of the grasslands into which they may be broadly divided, viz., excellent, good, fair and poor, depending on the type of grass cover (botanical composition) and percentage of ground cover[1]. The description of these classes is as follows :

(i) Excellent : 76 per cent and over contributed by 'Climax'* species ; plant cover 51 per cent or over.

(ii) Good : 51 per cent to 75 per cent 'Climax' species ; plant cover 26 per cent to 50 per cent.

(iii) Fair : 26 per cent to 50 per cent 'Climax' species ; plant cover 10 per cent to 25 per cent.

*By 'Climax' species is meant the species representing the highest stage of succession under the available climatic and edaphic conditions.

1 Agarwal, S. C. and Rege, N.D. 1960. Planning and managing grasslands, J. of Soil & Water cons. India, Vol. 8 (2 & 3).

(iv) Poor : 0 per cent to 25 per cent 'Climax' species ; plant cover less than 10 per cent.

After the condition classes of the grassland are determined, the different steps for their optimum utilisation may be taken.

Weed Control in Grasslands

25.4.10 One of the results of overgrazing is the invasion of both herbacious and shrubby weeds which compete with the useful species for soil moisture and plant nutrients, thus affecting production. In the trials conducted at IGFRI[1], it has been seen that in well managed grassland hay yield is about 42 quintals per hectare, yield decreased to 12.0 quintals per hectare and 5.5 quintals per hectare respectively in grasslands having on the average 1,800 and 3,500 bushes per hectare respectively, thus showing a great decline in yield. Bushes and weeds can be removed in various ways such as digging out, burning or by use of herbicides such as 2, 4, 5-T or Picloram. While use of fire as a means of eradication of weed could be made, it has to be borne in mind that in arid and semi-arid regions, burning accelerates the deterioration process. Fire can be used with caution in humid areas for destruction of bushes and shrubs.

Soil and Water Conservation in Grasslands

25.4.11 Depending on the topography and the soil condition, proper soil and water conservation methods should be an integral part of a good grassland management system. On degraded grasslands, therefore, specially on undulating terrain, one of the first measures that should be taken is to prevent any further erosion of soil. Depending on the extent of erosion, contour furrow and ridges should be put up to check further soil loss. Where gully formation has already taken place, check dams should be put up depending on the extent of gully formation. In arid and semi-arid regions conservation of available rain water is obligatory. Harrowing, contour furrowing or pitting helps in conservation of soil moisture. Diverting rain water through natural water courses to adjacent slopes by putting up small dams, can also be effectively used for "water spreading" in areas of scanty rainfall.

Ecological Management of Grasslands

25.4.12 There is a general consensus among ecologists that

1 Magoon, M.L. and Dabadghao, P.N. 1973. How to achieve potential grassland production, Indian Farming, Vol. 23 (5) : 15.

ecological management of grassland on the basis of known successional trends and the reaction of the species to different biotic factors, is the best and the cheapest means to effect improvement in grasslands. Management of any grass cover will naturally be based on growth cycle of the species, the rate of regeneration and reaction to defoliation, palatability and competitive ability etc. The system of management should be such as to favour regeneration and multiplication of the most desirable species and maintain the grassland under the optimum condition of productivity. In situation where degradation has proceeded to such an extent that the desirable species have almost been eliminated, ecological succession could be assisted by the reseeding of the desirable species under proper conditions of protection and management. For example, in arid and semi-arid regions of India, where the grass cover is of *Dichanthium, Cenchrus, Elyonurus* types, reseeding could be done with any of the constituent species or related species found under such a grass cover. Similarly, under *Sehima dichanthium* type, *Sehima nervosum* could be established in the degraded grassland in accompaniment with proper soil conservation measures. It may also be possible to assist in the regeneration of the grassland by using any one of the species found one stage lower in the succession such as *Chrysopogon fulvus* or *Eremopogon foveolatus*.

25.4.13 Depending on local conditions of topography one or the other of the following methods can be adopted for the reseeding of grassland :

(i) surface seeding by scratching of the surface soil with simple implement ;
(ii) sod seeding, whereby the seed is placed slightly below soil surface in the existing sod by special equipments ;
(iii) sowing of seed or planting of rooted slips or tillers in lines in the existing grassland ; and
(iv) aerial seeding of hill slopes in sheep rearing areas.

25.4.14 Reseeding of grassland is one aspect on which more information is required under different grassland types of various condition classes and under different systems of management. It is recommended that the above work on ecological improvement of grasslands both with or without reseeding under different condition classes should be undertaken by IGFRI, CAZRI and agricultural universities, which are already working on grassland improvement and management. It is also necessary to collect more information on viability and dormancy of the important grassland species normally available in India.

Multiplication of Grassland Seeds

25.4.15 Seeds of the important grassland species are not available

in any quantity and this has hampered grassland development work to a great extent. Although there is large demand for seeds of *Cenchrus ciliarus, Cenchrus setigerus, Dichanthium annulatum, Panicum antidotale* etc., there is no source in India which can supply these seeds in required quantities. It is, therefore, necessary that a seed production programme be undertaken by the organisations mentioned above. Forest departments should come forward particularly in the arid and semi-arid regions, to undertake a programme of seed production of the major grassland species. We have recommended in the Interim Report on 'Desert Development' that grassland development work in the desert regions should be undertaken by the forest department of the States covered and this should be implemented effectively and quickly.

Introduction of Legume Component

25.4.16 A suitable legume component, comparable to that of clover or alfalfa of the temperate regions, is lacking in Indian grasslands. It is well known that the quality of forage in Indian grassland is very poor. Although most of the grass species in the earlier stages of growth contain about seven per cent crude protein, it progressively declines to two per cent on maturity[1]. It would, therefore, be necessary to introduce a suitable legume component in our grasslands in order to improve the quality of the herbage and also to progressively improve the soil fertility. Trials are being made to introduce a number of legume species, both indigenous and exotic. Some success is reported to have been achieved in introducing *Atylosia scarboides* (*ban kulthi*) *and Macroptilium atropurpuraum*. It has been observed that even if the grass is harvested at the mature stage, as is normally done, protein content of the mixed herbage is over 6 per cent as compared to about 2 per cent of the pure grass hay.

25.4.17 The type of legumes available at present such as *Atylosia, Alysicarpus, Indigofera* etc. do not appear to be particularly promising for grazing of livestock. Work should be intensified to evolve high yielding cultivars of these species. At the same time, all-out efforts will have to be made to locate exotic species that could be introduced in Indian grasslands. Some species of *Stylosanthes* appear to hold some promise in this respect. The possibilities of using perennial species of groundnut (*Arachis*) as a grazing legume should be investigated. Perennial types of *Cajanus* may also hold some promise in this regard.

25.4.18 Animals graze selectively and the most palatable species are nipped off before they put forth new growth and thus the most desirable species in the grasslands are depleted much faster than the

1 Magoon, M.L. & Dabadghao, P.N. 1973. How to achieve potential grassland production, Indian Farming Vol. 23(5) : 15.

relatively unpalatable types. The need for proper protection from grazing cannot, therefore, be over-emphasised. Sufficient information[1] is available on the benefits derived from protection alone.

25.4.19 As mentioned earlier, the studies on grassland management were initiated in Bombay Presidency as far back as 1912 by Burns and his associates. In these studies wherever controlled grazing of the rotational types was practised, the following advantages were apparent[2]:

(i) the vegetation is afforded a chance to make better growth;
(ii) young and nutritious grasses become continuously available to the animals during the grazing period;
(iii) the grazing period becomes prolonged;
(iv) the cattle maintain good condition;
(v) inferior and coarse grasses gradually give place to superior types;
(vi) erosion is reduced; and
(vii) seedlings and saplings of forest trees are not damaged or browsed by cattle since sufficient grazing is available for the latter.

Application of Fertiliser

25.4.20 It is known that grasses and natural grasslands respond favourably to application of fertilisers. It was found in a study on soils fairly rich in calcium (Ca) and phosphorus (P) at a place near Nagpur that the effect of application of super-phosphate is marked by increased growth and consequently a higher yield of dry matter. Manuring with Ca and P is found to have a favourable effect on the mineral composition of plants grown in soils poor in these nutrients. Studies by CAZRI have shown that yields of grasses like *Elyonurus hirsutus*, *Cenchrus ciliaris*, *Cenchrus setigerus* and *Panicum antidotale* go up following the application of nitrogenous or phosphatic fertilisers. The increase is greater when these fertilisers are mixed and applied. Potash, however, has a depressing effect on yields of all the four species of grasses. At Coimbatore, a combination of farmyard manure plus ammonium sulphate was found to be the best in trials with *Cenchrus, ciliaris, Cenchrus glaucus Brachiaria mutica, Panicum maximum* and *Panicum antidotale*; *cenchrus, aglaucus,* was the most responsive species to manuring.[3] It will thus be seen that besides taking measures such as soil and water conservation, ecological management and reseeding as

1 (i) Kumar, L.S.S. and Godbole, S.R. 1933, Grassland investigations in Western India; Herbage Review Volume.
(ii) Kumar, L.S.S. 1946. Better utilisation of farm grasslands in Bombay Presidency; Indian Forestor, 72.
(iii) Albertson, F.W. 1958. How they are improving grasslands in Saurashtra; Indian Farming 8(9).

2 Whyte, R.O., Grassland and Fodder Resources in India, New Delhi, Scientific Monograph No. 22, Indian Council of Agricultural Research.

discussed in paragraphs 25.4.10—25.4.13 for increase in productivity of grasslands, periodic application of suitable fertilisers would greatly enhance the production of grasses.

25.4.21 We, therefore, recommend that intensive studies should be undertaken to ascertain the optimal mode of utilisation of fertilisers under different agroclimatic conditions for development of grasslands in different parts of the country. In extensive rangelands and grass reserves, which are not easily accessible, one way of application of fertilisers would be to form pellets by coating quality grass seeds with fertilisers and broadcast them if necessary from air, all over the area. In smaller grasslands, application of fertilisers should follow soil testing, and should be combined with tractor ploughing, selection of the most suitable grass or fodder species, introduction of legumes and scientific system of harvesting.

Controlled Grazing and Grassland Development

25.4.22 For proper utilisation of grasslands various systems of grazing, viz., controlled continuous grazing, rotational grazing, deferred and rotational grazing can be used depending on available grazing and number of animals. We have described in detail in the Interim Report on Desert Development, the system of rotational grazing to be adopted in desert areas. This system could be adopted with suitable modification in most States of central and western India where large scale grassland development is proposed to be undertaken. Steps to be taken for grassland development in the arid and semi-arid areas of Rajasthan, Gujarat and Haryana have already been indicated. The States in which grassland development programme should receive immediate attention besides the areas outside the arid and semi-arid areas of the above three States are Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Bihar, Orissa and subtropical as well as temperate and alpine region of Jammu and Kashmir, Uttar Pradesh, West Bengal and Arunachal Pradesh.

25.4.23 Though from time to time, a survey of the different categories of wastelands has been made, the magnitude of the problem is yet to be determined in many of the States. There has to be a systematic survey of such wastelands and village common lands in the different States for preparing a land use plan based on a village or group of villages as a unit. The land use plan should clearly indicate the areas which would be earmarked for grazing and for raising grass and fodder, fruit, fuelwood and timber species. In our Interim Report on Social Forestry, we have recommended that where a minimum area of 20 ha is available in a compact block, development of mixed forestry comprising raising of grass and leaf fodder, fruit trees and

other trees suitable for fuelwood and small timber should be taken up by the Forest Department. Protection should be the responsibility of the panchayats, with the income being divided equally between the panchayats and the Forest Department. Since grazing and fodder development are vital to the village economy, we have stated that development of fodder and grass should be an important component of mixed forestry which is to be taken up with optimum input and technology as elaborated in paragraphs 25.4.10—25.4.20. Besides the categories of land mentioned above, we have recommended in that Interim Report that all lands on the sides of roads, canal banks and railway lines should be brought under organised tree planting. In these areas there will also be considerable scope for growing grasses and fodder along with trees, and due regard should be given to this aspect while formulating programme of social forestry. The areas that cannot be covered under social forestry should be developed by the Animal Husbandry Departments for additional grazing and production of hay.

25.4.24 The survey of wastelands should include the assessment of all available Government land according to the size of the blocks. All blocks of over 200 ha should be taken up progressively for development as rangelands. In areas where blocks of lands owned by the Government are scattered and are of small sizes, steps should be taken for their consolidation. Rangeland development could be made by the Animal Husbandry and Sheep Development Departments. However where it is considered necessary to entrust the work to the Forest Department, there should be a regular consultation between the concerned officers of the Animal Husbandry/Sheep Development Department and the Forest Department for planning the range development programme.

25.4.25 We have, in the Interim Report on Desert Development, recommended creation of grass reserves for hay making and storage. The same procedure could be adopted for creation of grass reserves elsewhere under rainfed conditions, provided the blocks are of large areas and their protection is assured. Large blocks of Government rangelands of a minimum size of 200 ha, and preferably located far away from habitation, would be suitable for the purpose. In some States the Forest Department is at present entrusted with the management of grass reserves both inside and outside the forests. The Forest Department has thus some experience and expertise in this work, and so the programme of development of grass reserves should be entrusted to the Forest Department. To supplement the quantity of hay obtained from grass reserves and stored in fodder banks, the village panchayats and individual farmers may also be encouraged to conserve the grass on a cooperative basis, and necessary extension assistance should be provided by the specialists in the Departments of Forest, Animal

Husbandry, Sheep Development, Dairy Development and Agriculture.

25.4.26 Pasture demonstration plots established under the Key Village Scheme in Rajasthan have shown that fencing, reseeding and other measures considerably improve the carrying capacity of village common grazing lands. Such demonstrations on larger plots of lands should be undertaken on an extensive scale. Large plots of Government grazing lands near the villages should serve the purpose of demonstrating the usefulness of such grassland management techniques to the village panchayats and farmers. All extension media, including audiovisual aids such as films/slides, should be used to educate the farmers on the need for proper protection and regulated utilisation of the grassland.

25.4.27 In order that grassland development may become economic, this programme should be combined with that of the improvement of livestock. Grassland development can become economic only if the produce from this land is fed to the high yielding stock and thereby better return is obtained in the form of livestock and dairy products. If this is done then the owners of the livestock will be in a position to pay a reasonable price for the hay as well as for the fees for controlled grazing. For the purpose of grassland development extensive areas would be needed and for this we recommend that the existing pastures and grazing lands as also the village common lands and wastelands which are intended to be brought under social forestry and other grassland development schemes should not be allotted to landless labourers in the 'land for landless' programmes. The economy of the landless labourers can be better secured by providing facilities for better grazing and feeding of hay to their animals than by allotting to them small areas of poor quality lands, the upkeep of which would be burdensome for them.

5 TREE AND SHRUB LEAVES AS FODDER

25.5.1 Cattle and buffaloes are generally fed on cultivated fodders and other agricultural byproducts and grazing, and sheep are maintained on grazing and shrubs, while in almost all parts of the country animals like goats and camels are fed on leaf fodder from shrubs and trees. The fodder shortage is experienced during November-June especially in hilly and drought prone areas, where shrubs and loppings from the trees are fed to all kinds of livestock. Tree and shrub fodder as such is scarcity fodder particularly for cattle and buffaloes under the present condition of shortage of fodder. There are only very few areas, apart from the reserved forests, where lopping of trees is regulated.

Even in the forest areas, it is becoming increasingly difficult to control lopping and cutting of shrubs for fodder, in view of the pressure of the livestock population. In the Inner Himalayas, suitable broad-leaved trees, particularly the evergreen oak, are lopped on a regular rotation and carefully preserved, where a farm has trees allotted to it. Elsewhere in the forests or in the common village pastures, no such care is taken and no tree is spared. Generally everywhere in the country there is little attempt at regulation of lopping of trees in private forests, scrub jungles, common village lands, and avenues while trees are often lopped to death.

25.5.2 The most common fodder trees in different altitudinal climatic zones in the Siwalik hills and the Himalayas are given in Appendix 25.1. There are a large number of trees which are lopped in different parts of the country. In the arid regions, the most important of the indigenously available trees are *khejri* (*Prosopis cineraria*) and *ber* (*Ziziphus* sp.). *Anjan* (*Hardwickia binnata*) is a popular source of tree fodder in the Central India. Some of the common trees of wide occurrence in India used for fodder are *babul* (*Acacia nilotica*), *neem* (*Azadirachta indica*), *siris* (*Albizzia* sp.), *mulberry* (*Ficus* sp.), *jaman* (*Eugenia jambolana*), *sissoo* (*Dalbergia sissoo*), *kanthal* (*Artocarpus integrifolia*), *Bauhinia* sp., *bel* (*Aegle marmelos*) etc. The feeding of anjan leaves and chaffed *Ziziphus* bush to milch animals is very common in areas with low rainfall, while the evergreen oak is popular with farmers in hilly areas. Green leaves of *Albizzia* sp. are frequently used in and around the Salem and North Arcot districts of Tamil Nadu. Plantation of these fodder trees on farm boundaries, village surroundings, road sides, along railway tracts, canal banks and in common grassland and as part of social forestry can go a long way to overcome grazing and fodder shortages. We, therefore, recommend that plantation of fodder trees should be taken up as part of social forestry.

25.5.3 Sporadic efforts have been made in the past to improve the feeding value of various leaf fodder materials, but they have mainly remained cloistered in research laboratories. It has been reported[1] that the feeding values in respect of DCP of some species of tree leaves and shrubs like *siris*, sianjana (*Moringa oleifera*), mulberry or *tut*, *bel*, *marorfali* (*Helicteres isora*), *bhemal* (*Crewia oppositifolia*), etc. compare quite favourably with grains like barley, oats and byproducts like cereal brans; for example, a mixture of 10 kg of *marorfali* leaves (fresh and green) and 1.5 kg of maize or barley yield 0.5 kg of DCP and 3.7 kg of TDN, and provide enough nutrients for producing 10 kg of milk of 5 per cent milk fat. It can, therefore, be seen that green tree leaves fed at a stage when they are digestible and palatable can

1 Jayal, M. M., Rajahans S. K. & Sawhney P. C. 1973. Feeding of Livestock during scarcity period, Animal Nutrition Division, Indian Veterinary Research Institute.

substitute concentrates. We recommend that the Animal Nutrition Division of the IVRI, the NDRI and agricultural universities should undertake to study nutritive values of various tree leaves and bring out Extension Bulletins for the information and use of field staff, individual farmers and farm cooperatives etc. The Directorate of Extension of the Union Ministry of Agriculture and Irrigation should also undertake popularisation of the feeding of tree leaves to livestock through audio-visual aids and Farm Information Bulletins, giving hints on method of growing fodder trees and proper and timely pruning and lopping. Dissemination of such information would be useful for the farming community.

6 SEEDS OF FODDER CROPS

25.6.1 The non-availability of improved seeds of different fodder varieties has been and still is one of the major constraints which have hampered fodder and grassland development activities. Even now there is no organised industry for production, certification and distribution of seeds of herbage and fodder plants. The National Seeds Corporation (NSC) has taken up multiplication of a few selected fodder crop seeds but its present programme cannot meet a fraction of the demand and therefore seeds are purchased from the open market without any guarantee. The importance and the role of multiplication of seeds at different stages viz. nucleus, foundation and certified seeds have been dealt with in details in Chapter 47 on Seeds. What has been said there about seed production in general is also relevant in the case of fodder crop seed production. We are, therefore, dealing in this section with only some special aspects of this topic while we would invite a reference to the other chapter for detailed information.

Breeder Seeds

25.6.2 Research work on fodder crops is being conducted by the IGFRI and agricultural universities. The Coordinated Project on Forage Crops under which tests are conducted under different agroclimatic conditions throughout the country can identify the variety most suitable for a particular region. After these varieties are identified one Institution/Organisation may be assigned the duty of multiplying breeder seed for further production of foundation seed of fodder crops. The responsibility of organising production of breeder seeds and coordinating this work on all-India level should be with

the ICAR. Rigorous checks on the quality of fodder seeds produced at this stage should be carried out by the respective breeders themselves. It is important that sufficient quantities of breeder seeds are produced so that lack of fodder seed does not become a constraint in the development programme. This should be a normal feature before the release of a new fodder variety for field adoption. Breeder seeds of improved varieties should be made available to the NSC, the centrally administered regional stations for forage production and demonstration as well as to the State Government agencies where facilities exist for seed multiplication under controlled conditions.

25.6.3 It has been brought to our notice that non-availability of adequate quantities of breeder seed of fodder crops has been the major hurdle in the seed production programmes of NSC. We, therefore, recommend that the ICAR should take immediate steps for streamlining the production of breeder seed of the already evolved varieties of fodder crops, so that the NSC and the other agencies involved could start multiplication of the seeds in the required quantities.

Foundation Seed

25.6.4 For production of foundation seeds of fodder crops of regional importance, the primary responsibility should lie with the State Governments. In case necessary facilities for seed production such as fodder crop seed production farms are not available with the State Governments, the latter should specifically nominate or create one or more institutional agencies depending upon the circumstances. It has been observed that the State seed corporations do not normally take up production of fodder seeds. In the present state of development of animal husbandry, we feel this policy would not be in the national interest. We, therefore, recommend that wherever State seed corporations exist they should take up the production of foundation seeds of fodder crops as well, even when such a venture is not profitable to the corporation in the initial stages. It is emphasised that each State should develop a seed certification agency for fodder seeds. In case such an agency already exists in respect of food crops, the same agency should be assigned the responsibility of certifying fodder seeds.

Certified Seed

25.6.5 In the Interim Report on Multiplication and Distribution of Quality Seed Pertaining to High Yielding Varieties and Hybrids of Cereals, we suggested that services of five possible agencies could

be utilised for the purposes of production and distribution of certified seeds. These are (a) seed corporations, (b) seed co-operatives, (c) seed growers organisations, (d) agro-industries corporation and (e) private agencies. In the case of seeds of fodder crops one or more of the aforesaid agencies could be utilised for seed production and the services of registered growers may also be drawn upon for multiplication of the certified seeds. In fact, in the preliminary stages of introduction of high yielding varieties, it may be desirable to engage registered growers for seed production, as growers who are also actual users of the seed, may help in the promotion of fodder crop cultivation. In this case, however, the State Government should give suitable incentives and arrange to buy surplus seeds, if any, from these growers. As already indicated earlier, the State Government should develop an appropriate machinery for proper check and quality control of seeds produced not only by registered growers but by other agencies as well.

25.6.6 Till such time separate agencies and organisations are created in the States for multiplication of fodder seeds, it is necessary to utilize all available facilities and infrastructure to the maximum extent possible. During the Fourth Plan period, 38 fodder seed production farms were established in the country.* This includes some cattle breeding farms where areas have been earmarked for fodder seed production and existing facilities are being utilised for the purpose. Wherever land is earmarked within the cattle breeding farms for this purpose, it is to be ensured that the area earmarked is adequate, and the seed production farm is operated efficiently so that maximum seed is produced. At present, almost all the seeds produced at these farms are being utilised for fodder production at the State Government cattle farms and very little seed is being used for developmental purposes. In order that the State Governments become self-sufficient in supply of fodder seeds for all fodder crops of local importance, either larger areas will have to be earmarked in the farms or additional farms will have to be established. Furthermore, the fodder crop seed production farms already established during the Fourth Plan period, should be provided with all the necessary inputs, viz., machinery, equipment, staff etc. so that the farms become fully productive. For a vast country like India with diverse requirements, 38 fodder seed production farms will not be able to meet the requirements of foundation and certified seeds even if these function effectively. It is therefore necessary to establish additional farms as soon as possible or facilities available with the existing agriculture and cattle farms be augmented.

25.6.7 The cost of quality seed will naturally be high. There

* Draft Fifth Five Year Plan, Planning Commission, Government of India.

are, however, ways by which it is possible to keep the cost within reasonable limits. First, a regular and constant demand for quality seeds must be created among the cultivators. They must realise that the higher price they pay is but little compared to the benefits they will derive by use of quality seeds. Once farmers become conscious of the benefits of using better seeds they will not hesitate to pay a little higher price for them. A vigorous extension programme including actual demonstration in the farmers' fields must be conducted with the improved high yielding varieties, so that they may see the difference between the new varieties and those being used by them. As mentioned earlier, in States the seeds of fodder crops for demonstration purposes are purchased from the open market regardless of the quality. This practice must be done away forthwith as it does more harm than good. In case the State Governments are unable to procure certified seeds of any particular fodder variety, it is better that no demonstrations are conducted on that crop. We are told that some of the State Governments hesitate to purchase seeds from NSC as the prices are higher than the market prices. We suggest that decision must be taken by the State Governments to allow the concerned departments to purchase seeds from the NSC or certified seeds from any other reputable sources without calling for tenders, so that the extension programme on fodder promotion is not hampered. Unless demonstrations are conducted with high quality seeds the extension programme can never be a success.

25.6.8 We also suggest that the minikit demonstration programme on fodder crops should be initiated on the same lines as Rice Minikit Programme conducted by the Department of Agriculture in order to popularise new high yielding varieties and to cover a large number of farmers.

25.6.9 The department charged with extension work of fodder crops should arrange to supply certified seeds to farmers well in time and make necessary arrangements for their storage of seeds at district headquarters or at the locations where other seeds are preserved for distribution. In case the fodder seeds are to be kept for more than one year, necessary precautions should be taken to keep the seeds under proper conditions. Grass seeds lose viability very quickly and it is necessary to control humidity rigorously for their preservation.

7 ORGANISATIONAL ASPECT

25.7.1 In a vast country like India with diverse agroclimatic conditions, the requirements of research in fodder of each region of the

country would be specific and different. Special research projects should therefore be undertaken to cater to the needs of each region. At present the emphasis laid on research work on fodder crops in the agricultural universities is not uniform. It is desirable that all of them devote adequate attention to this field. The Haryana Agricultural University has created a separate department of fodder crops. We recommend that other agricultural universities should similarly create a separate department or unit to deal with fodder of all types in an integrated manner.

25.7.2 Earlier in this chapter we have pointed to the absence of a suitable organisation to look after the needs of the development programmes on feeds and fodder. The sub-committee of the Central Council of Gosamvardhana very pointedly emphasised as early as 1961 this fact and had suggested the creation of Animal Feed and Forage Board in each State with a similar board at the Centre. It was recommended that these boards should be entrusted with full executive powers and responsibilities and provided with separate personnel, budget, equipment etc. to effectively carry out the programme on their own. It was also suggested that these boards could eventually be converted into departments. The aforesaid sub-committee also suggested the appointment of an Animal Feed and Forage Development Commissioner and his duties and responsibilities were indicated in detail in the Committee's Report. None of the aforesaid recommendations have been implemented so far. This shows the low priority being attached to this important sector of livestock development.

25.7.3 At present the Department of Animal Husbandry in most of the States is responsible for fodder development. The present set-up of the department, insofar as fodder development is concerned, is, however, extremely inadequate considering the magnitude of the task. The staff consists of one Fodder Development Officer—generally of the Class II service of the State Government—and assisted by one or two Technical Assistants but with no field staff. In most of the States the Fodder Development Officer is taken on deputation from the Department of Agriculture. As such there is no avenue of promotion in the Department of Animal Husbandry for him and this creates lot of dissatisfaction among the staff as a result of which the work suffers. In some States the Fodder Development Officer is a veterinary graduate and thus lacks necessary expertise in fodder production. It will not, therefore, be wrong to say that fodder development organisation exists only in name since it hardly comprises two to three officials for the whole State. It is not surprising that no significant headway has been made in this field. We are of the opinion that a strong organisation should be set-up in each State to

look after the activity right down to the field level.

25.7.4 We have indicated earlier the importance and the necessity of fitting in fodder crops, particularly legumes, in the major crop rotations. It is the responsibility of the Department of Agriculture to formulate suitable crop sequences for the different agroclimatic conditions. After giving due consideration as to the department which should be entrusted with the responsibility of fodder development, we have come to the conclusion that development aspects of fodder crops can be taken care of more effectively by the same organisation which deals with the food and cash crops and which has already a large extension organisation from the State headquarters down to the field level. This appears to us to be the most suitable arrangement unless a complete hierarchy is to be set up in a separate department or in the Animal Husbandry Department. Fodder production is a comparatively new field in which new techniques are being developed for maximising yields under different conditions. Management of fodder crops (for optimum production of fodder and seed) is difficult and complex and requires a thorough knowledge of the crop, and techniques of soil and water management for which a basic knowledge of agronomy is necessary. Therefore, the Department of Agriculture should be in a much better position to undertake this responsibility. We would, however, like to emphasise that the Agriculture Department of the State should give this programme full attention. It would be desirable that the Agriculture Department creates a separate and strong wing at the headquarters headed by a senior officer not below the rank of a Joint Director for this work. This officer should not be entrusted with any other crops so that he is able to devote his entire attention to this important work. In addition, there should be one Fodder Development Officer in each region within the State and Fodder Development Assistants at the district levels. The activities concerning fodder promotion at the block and the village levels may be conducted by the regular extension officials of the Department of Agriculture under the overall guidance of the Fodder Development Officer. Besides extension activities it will be the responsibility of this wing to arrange for the production of seeds of fodder crops at the fodder seed production farms and cattle breeding farms where areas are set apart for seed production, and by registered growers. It should also arrange for timely supply of such seed to farmers.

25.7.5 We are convinced that unless a strong base is created for undertaking a massive extension programme on fodder crops (including production and supply of improved fodder crop seeds) it would be extremely difficult to achieve the targeted production of

green fodder to meet the requirements of the livestock sector. But mere conduct of demonstration with improved varieties and improved packages of practices in the farmers' fields will not serve the purpose. The department should be able to advise the farmers on proper rotations to be followed for production of fodder on year-round basis depending on individual resources and facilities available, so that these farms are run efficiently and make profit. It would then be in a position to assist the small farmers and farmers of field crops in switching over to mixed farming thereby ensuring greater return and stability of the farming unit. To ensure proper co-ordination it would be advisable for the concerned officials of the two departments to meet well before each crop season and do the planning for fodder development together.

25.7.6 So far as grassland improvement is concerned, we have indicated earlier in Section 4 the responsibilities that may be assigned to the Forest, Animal Husbandry/Sheep Development Departments in this regard. The programmes of rangeland development and management, grass reserves and mixed forestry with grass and fodder development envisage coverage of a vast area. In order to handle these programmes effectively, it would be necessary to strengthen all these departments. In our Interim Report on Social Forestry, we have urged the creation of an extension wing in the Forest Department. Where a large programme of grassland development is taken up by the Forest Department, they should employ adequate number of agrostologists, agronomists and range management specialists. It should also be ensured that once the programme of grassland development, including grass reserves, is taken up by the Forest Department, the areas should on no account be converted later into forest plantations. Where large areas are taken up for grassland development by the Animal Husbandry and Sheep Development Departments, a separate wing should be created in these departments. The strengthening of the infrastructure would necessarily vary from State to State, depending on the availability of large blocks of grasslands and on the development programmes to be undertaken. As such, no general recommendation with regard to the type of organisation to be created is given. However, in States like Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu etc. where there are sizeable areas under grasslands a separate unit headed by an officer not below the rank of a Deputy Director should be created to undertake a progressive and time-bound programme for development. Other field staff should be provided for undertaking actual development activity depending on the extent of the programme. It is extremely important that adequate funds should be provided for taking up the grassland development programme on the same lines as suggested in the Interim Report on Desert Development.

25.7.7 Grassland development is a specialised job, and this can be properly done by trained and qualified agrostologists and agronomists. It is, therefore, necessary that the implementation wings for grassland development in the Forest, Animal Husbandry and Sheep Development Departments should be carried out by specialists with sufficient knowledge and experience in this field. In the Forest Department, the supervisory staff in higher cadres should be employed on a long term basis to facilitate their gaining experience and in making use of such experience on a continuing basis. Action should be taken to train adequate number of specialists both within the country and abroad specially in countries where grassland and range development is highly advanced. This is essential as sufficient technical knowhow is not at present available in the country.

25.7.8 Both cultivated fodder and grassland development are necessary for implementation of the livestock development programmes. It is, therefore, essential that in every State there should be a machinery for proper co-ordination and implementation of cultivated fodder and grassland areas. This can be best organised by setting up a standing co-ordination committee in each State as already recommended in our Interim Report on Desert Development. We recommend that every State should constitute a State-level standing committee for the proper planning and execution of the fodder and grassland development programmes. This State-level committee should be headed by the Agricultural Production Commissioner and should have as members heads of the Departments of Agriculture, Forest, Soil Conservation, Dairy Development, Sheep Development and Animal Husbandry. Representatives of the Irrigation and Revenue Departments should also be included in it. The Director of Animal Husbandry Sheep Development should be the Member Secretary of this Committee. This committee should assess feed and fodder requirements of the State, review the progress of grassland and fodder development activities, co-ordinate the activities of concerned departments in the field of grassland and fodder development, lay down the policies and time-bound action programmes and take effective steps for implementation of these programmes through the various concerned departments. Similar co-ordination committees should be set up at the district level with representation from the various concerned departments under the chairmanship of the Chief Agriculture Development Officer.

25.7.9 At the Central level in the Department of Agriculture, there is a small unit charged with the responsibility of fodder and grassland development. It is at present headed by a Deputy Commissioner. This unit will be required to provide technical guidance. It would be highly desirable that this unit should be adequately strengthened to

meet the requirements of the much enlarged programmes visualised and recommended by us earlier. The Committee of Livestock Feed and Fodder set up by the Union Ministry of Agriculture recommended the creation of a post of Joint Commissioner for this purpose. We endorse this recommendation strongly. Besides creating the post of Joint Commissioner, it would be necessary to add adequate staff to this unit.

8 SUMMARY OF RECOMMENDATIONS

25.8.1 The following is a summary of the important recommendations made in this chapter.

1. The available feed resources being extremely limited should be distributed in such a manner that these are put to best use for increasing the production of milk, meat, wool, eggs, etc.

(Paragraph 25.1.4)

2. There should be a strong research base for undertaking effective programmes for the evolution of high yielding, nutritionally superior and disease resistant varieties and for standardisation of package practices as applicable to different agroclimatic regions. Massive farmer-oriented extension programmes both for fodder production and conservation should be organised.

(Paragraph 25.1.6)

3. Efficient arrangement for production and supply of high quality fodder seeds should be made.

(Paragraph 25.1.6)

4. Selection and introduction of high yielding fodder varieties need attention.

(Paragraph 25.3.5)

5. High yielding fodder varieties are usually shy seeders. Efforts should therefore be made to incorporate high seed yielding character in them.

(Paragraph 25.3.6)

6. Efforts should be made to combine high nutritive quality with high yield.

(Paragraph 25.3.7)

7. Dual purpose and multi-cut legume fodder varieties which can overlap the fodder scarcity periods, May—June and October—November should be evolved for inclusion in crop rotations.

(Paragraph 25.3.10 and 25.3.11)

8. Arrangements for seed production of the root crops with high tonnage should be made in the hills of northern India.

(Paragraph 25.3.13)

9. Suitable high yielding, quick growing and shade tolerant legumes which can combine well with cultivated fodders should be evolved for irrigated as well as rainfed areas.

(Paragraph 25.3.14)

10. In order to build up the required germplasm collection, experts should be sent to tropical and subtropical countries to locate promising grasses and legumes.

(Paragraph 25.3.15)

11. Optimum sowing and harvesting schedules should be determined for each fodder crop for each region.

(Paragraph 25.3.17)

12. In rainfed areas where premonsoon showers occur, possibilities of growing short duration fodder crops should be exploited.

(Paragraph 25.3.19)

13. Studies on the economics of fodder crops grown as a mixed crop with broadly spaced food or cash crops and as a single crop should be carried out.

(Paragraphs 25.3.20 to 25.3.22)

14. It is necessary to limit the stocking rate of grasslands and to undertake measures for improvement of their productivity by controlled grazing.

(Paragraph 25.4.6)

15. In grasslands of arid and semi-arid regions, conservation of rain water by gully plugging, putting small dams, removing shrubs etc. should be practised.

(Paragraph 25.4.11)

16. In degraded grasslands, reseeding of desirable species with proper management should be resorted to.

(Paragraph 25.4.12)

17. Work on ecological improvement of grasslands should be undertaken by the institutes working on grasslands management.

(Paragraph 25.4.14)

18. Grass seed production programme should be undertaken by the organisations presently conducting researches on these aspects.

(Paragraph 25.4.15)

19. In order to improve the herbage quality and the soil fertility, it is necessary to evolve and introduce a suitable legume component in grasslands.

(Paragraph 25.4.16)

20. Intensive studies should be undertaken to ascertain the optimal mode of utilisation of fertilisers in grasslands.

(Paragraph 25.4.21)

21. A systematic survey of wastelands and village common lands should be made to prepare a land use plan as part of social forestry incorporating therein programmes of development of fodders and grasses. The wastelands not covered under social forestry programmes should be developed by the Animal Husbandry Department for additional grazing and production of hay.

(Paragraph 25.4.23)

22. While formulating programmes of social forestry on lands on the sides of roads, canal banks, and railway lines due regard should be given to the growing of grasses and fodder along with trees.

(Paragraph 25.4.23)

23. Available land in possession of Government, consolidated where necessary, in blocks of over 200 ha should be taken up progressively for development as rangelands by the Animal Husbandry and Sheep Development Departments. Where the work is to be entrusted to the Forest Department, there should be a regular consultation between the concerned officers of these departments.

(Paragraph 25.4.24)

24. Large blocks of Government rangelands located far away from habitation should be developed as grass reserves for hay making and this could be entrusted to the Forest Department if necessary. The village panchayats and individual farmers should also be encouraged to conserve grass on a cooperative basis.

(Paragraph 25.4.25)

25. Government lands, developed as grazing lands, should also serve as demonstration plots to the village panchayats and farmers. All extension media should be used to educate the farmers on the need for proper protection and regulated utilisation of grasslands.

(Paragraph 25.4.26)

26. In order that grassland development becomes economical, the programme should be combined with that of improvement of livestock.

(Paragraph 25.4.27)

27. Existing pastures, grazing lands, village common lands and other wastelands to be brought under social forestry and other grassland development programmes should not be allotted to landless labourers.

(Paragraph 25.4.27)

28. Planting of fodder trees on farm boundaries, village surroundings, along road sides, railway tracks, canal banks and in grasslands

should be encouraged as part of social forestry.

(Paragraph 25.5.2)

29. The Indian Veterinary Research Institute, National Dairy Research Institute and the agricultural universities should undertake trials to find out the nutritive value of leaves of fodder trees.

(Paragraph 25.5.3)

30. The Directorate of Extension of the Union Ministry of Agriculture and Irrigation should bring out suitable farm bulletins on growing, proper lopping/pruning etc. of fodder trees.

(Paragraph 25.5.3)

31. The Indian Council of Agricultural Research should take immediate steps for streamlining the production of breeder seed of the fodder varieties already evolved so that agencies like National Seeds Corporation, Regional Forage Production-cum-Demonstration Stations etc. could start seed multiplication.

(Paragraphs 25.6.2 and 25.6.3)

32. The State Seed Corporations should take up production of foundation and certified seeds of fodder crops and should develop their own seed certification agency.

(Paragraph 25.6.4.)

33. The services of the various seed corporations, seed co-operatives, seed growers organisations, agro-industries corporations and private agencies should be utilised for the production and distribution of certified seeds. Registered growers should be encouraged by means of incentives to produce seeds of fodder crops.

(Paragraph 25.6.5)

34. The State Governments should develop a machinery for proper check and quality control of seeds produced by all the agencies engaged in seed production.

(Paragraph 25.6.5)

35. The existing fodder crop seed production farms should be provided with necessary inputs like machinery, equipment, staff etc. so that maximum production could be achieved.

(Paragraph 25.6.6)

36. As the requirement of improved fodder seed is very large, additional fodder seed production farms should be established. A regular and constant demand for quality seed should be created among cultivators through extension and holding demonstrations on the farmer's field.

(Paragraph 25.6.7)

37. Minikit demonstration programme on fodder crops should be initiated on the lines of 'Rice Minikit Programme'.

(Paragraph 25.6.8)

38. Proper storage arrangements for seeds specially of grasses should be made at each district headquarters since these quickly lose viability unless properly stored, and they should be supplied to farmers well in advance of sowing time.

(Paragraph 25.6.9)

39. Agricultural universities should have separate departments or units devoted to cultivated fodders and pasture grasses.

(Paragraph 25.7.1)

40. The present official set-up for fodder development is extremely inadequate. Considering the magnitude of the task, a much stronger organisation should be set-up in each State for this purpose and this should function preferably under the Agriculture Department.

(Paragraphs 25.7.3 and 25.7.4)

41. To achieve the targeted production of green fodder, a strong base for undertaking massive extension programme should be created.

(Paragraph 25.7.5)

42. For grassland development, the Forest Departments should employ adequate number of agrostologists/agronomists and range management specialists. Areas once taken up for grassland development, including grass reserves, should not be converted later into forest plantations.

(Paragraph 25.7.6)

43. In every State, where there are large areas under grasslands and wastelands outside the programme taken by the Forest Department, the Department of Animal Husbandry should create a separate wing for their development.

(Paragraph 25 7.6)

44. Since grassland development is a specialised job. adequate number of specialists should be trained within the country as well as abroad to man the higher supervisory cadres to whom all development work should be entrusted.

(Paragraph 25.7.7)

45. Every State should constitute standing committees both at State and district levels for coordination in planning and execution of fodder and grasslands development programme.

(Paragraph 25.7.8)

46. The fodder and grassland development unit in the Union Ministry of Agriculture and Irrigation should be strengthened.

(Paragraph 25.7.9)

APPENDIX 25.1

(Paragraph 25.5.2)

Tree Fodder Species Recommended for Introduction in the Siwalik—Himalayan Region[1]

Siwalik foothills (1,100 to 2,000 ft.)

Albizzia lebbek	*Morus alba*
A. procera	*M. indica*
Bauhinia variegata	*Ougeinia dalbergioides*
Butea frondosa	*Prosopis juliflora*
Cordia dichotoma	*Salix babylonica*
Dendrocalamus strictus	*Salmalia malabarica*
Eugenia jambolana	*Ziziphus jujuba*
Grewia asiatica	etc.

Siwalik Hill Ranges (2,000 to 4,000 ft.)

Alblzzia chinensis	*Morus alba*
A. lebbek	*M. indica*
A. procera	*Olea cuspidata*
Bauhinia purpurea	*Ougeinia dalbergioides*
B. varlegata	*Populus nigra*
Butea frondosa	*Prosopis juliflora*
Celtis australis	*Prunus puddum*
Cordia dichotoma	*Quercus glauca*
Dendrocalamus strictus	*Robinia pseudo-acacia*
Emblica officinalis	*Salix babylonica*
Eugenia jambolana	*Salmalia malabarica*
Ficus glomerata	*Terminalia arjuna*
F. roxburghii	*T. tomentosa*
Grewia elastica	*Ziziphus jujuba*
G. oppositifolia	etc.

Outer Himalayas (4,000 to 6,000 ft.)

Albizzia chinensis	*Myrica nagi*
Bauhinia purpurea	*Populus alba*
B. variegata	*P. ciliata*
Celtis australis	*P. nigra*
Ficus roxburghii	*Prunus puddum*
Grewia oppositifolia	*Quercus glauca*

1 Whyte, R.O., 1964. The Grassland and Fodder Resources of India, pp. 163-164. New Delhi, Indian Council of Agricultural Research.

APPENDIX 25.1 (*Contd.*)

Morus alba	*Q. incana*
M. indica	*Robinia pseudo-acacia*
M. serrata	*Rhododendron arboreum*
Murraya exotica	*Salix alba* etc.

Inner Himalayas (6,000 to 10,000 ft.)

Betula utilis	*Prunus puddum*
Buxus sempervirens	*Quercus dilatata*
Celtis australis	*Q. incana*
Corylus colurna	*Q. semecarpifolia*
Morus serrata	*Rhododendron arboreum*
Populus alba	*Robinia pseudo-acacia*
P. ciliata	*Salix daphnoides*
Prunus cornuta	*S. wallichnaa*

Alpine Zone (10,000 ft. upwards)

Betula utilis	*Salix denticulata*
Corylus colurna	*S. daphnoides*
Prunus cornuta	*S. wallichiana*
Quercus semecarpifolia	*Taxus baccata*

26

SERICULTURE

1 INTRODUCTION

26.1.1 Silk is obtained from the cocoons of silkworms. Its production has four components, viz., (a) cultivation of host plants of silkworms, (b) rearing of silkworm up to cocoon stage, (c) reeling of cocoons into continuous filaments called raw silk and (d) silk-throwing and weaving by which filaments are twisted and woven into fabrics. The first component is an agricultural field operation. The second and third components are done indoors in leisure hours as cottage enterprise at present. The fourth one is indeed an industrial venture, but at present it is also done mostly as a cottage industry. Sericulture can be fitted in the lean or leisure periods of farmers and can be an important source of additional income for them. It can beneficially engage women, old and handicapped members of farmers' families. India occupies an enviable position in the field of sericulture as it is the only country producing all the four known kinds of silk, viz., mulberry *tasar,* eri and *muga.* Sericulture is by its very nature highly labour-intensive. Some of the developed countries, however, can ill-afford to divert their labour force from more productive fields to the production of raw silk. Before World War II, France which was an important silk producing centre, has now very little silk production. Production in Italy has considerably shrunk. Many other countries may perforce have to give up silk production. At the same time, the demand for silk fabrics is not likely to diminish. Silk has become a status symbol and its demand is bound to increase with increasing incomes. Silk has an important place in parachute manufacture. In so far as silk garments are concerned, natural silk has to face competition from man-made synthetics, but if Japan's experience is any pointer, even synthetics are not going to influence the demand for natural silk. Japan is one of the most advanced countries in the production of synthetic fibres and yet natural silk has not lost its appeal there. The advantages of man-made fabrics are comparative cheapness, durability and easy care, but silk has its own advantages, e.g., softness, fineness, hydroscopic nature and dyeing characteristics. Therefore, it is easy to foresee an

ever-increasing preference for silk garments. On the one hand, though developed countries may not be able to spare labour to undertake its production, on the other, the demand for natural silk may go on increasing. In this situation, India with her large labour force, is likely to play a much greater role in meeting the increasing world demand.

It is worthwhile to note that sericulture industry yields pupae oil and pupae meal as byproducts, the latter proving useful as fish and poultry feed. With the progress of industry, such byproducts can become substantial enough to add to the income of those in this profession. This aspect is dealt with in a separate Chapter on industrial uses of all kinds of agricultural products in one place.

26.1.2 Mulberry silkworm, *Bombyx mori*, is a domesticated insect and it thrives on mulberry (*Morus alba*) leaves. It is either univoltine or multivoltine depending upon whether it has one life cycle in a year or more. In the case of univoltine races, the insect is reared during the period May to September in north western parts of India. Univoltine races are fed on leaves derived from mulberry trees which are found wild or grown in the regions concerned. In the case of multivoltine races, mulberry is raised as bush as a regular field crop and 5 to 6 broods of silk-worm are taken in a year, e.g. in Karnataka and West Bengal.

26.1.3 Eriworm, *Philosamia* (*Attacus*) *ricini*, is also a domesticated insect. Its main host plant is castor, but it has other hosts too, e.g. kessari (*Heteropanex fragrans*) and tapioca. It is a multivoltine race and can be reared throughout the year. It is reared generally four times a year. Cocoons are obtained in two flushes, i.e. August-November and April-May. Rainy season is ideal for rearing in the State of Assam, which is the main eri silk producing State.

26.1.4 *Tasar* worm, *Antheraea* sp., is not amenable to indoor rearing. It does not feed or pair in captivity. Attempts are being made to alter this position through research. It is watched and fed in nature in jungles and only its cocoons are collected at the right time. It feeds on oak, *asan* (*Terminalia tomentosa*) and *arjun* (*Terminalia arjuna*), *sal* (*Shorea robusta*) and many other plants. The season for *tasar* rearing activity is between August and December. A crop beyond this period is not taken, because there is a marked deterioration in the size of cocoons and quality of the fibre, but such cocoons, if collected at all, are collected wild during leaf fall (i.e. towards March). *Tasar* culture, i.e., the production of cocoons, is largely confined to the forest belt of Chotanagpur (Bihar) and adjoining parts of Orissa. It is an occupation of Adivasis who live on the collection of minor forest products.

26.1.5 *Muga* worm, *Antheraea assamensis*, is a kin of *tasar* worm. It is less taxing than *tasar* worm, because it is a semi-domesticated

insect. Cocoon formation, pairing and egg laying are accomplished indoors; only the rearing of caterpillars has to be done outdoors over trees. It is a multivoltine silkworm producing five broods per year. The five broods usually are harvested in autumn, winter, summer, early rainy season and late rainy season. Autumn and summer crops are important for commercial purposes. Rainy season and winter crops are low in silk content and, therefore, are mainly used for seed. This race is perpetually retained in some of the hilly tracts because the worms degenerate when they are reared in the plains. It feeds on the leaves of several kinds of trees, the most common trees being *som* (*Machilus odoratissima*) and *soalu* (*Tetranthera monopetala*). *Muga* culture is confined to Assam and is a profession chiefly of tribals.

26.1.6 Mulberry silk is the most important in world production of silk. India produces about 2,000 tonnes of mulberry silk annually. Its position in relation to world production is shown in Table 26.1. Its contribution to world production is a mere 5 per cent, whereas Japan and China put together account for 75 per cent. Its place was fourth, but is now fifth having been outplaced by South Korea. Of the other countries, Latin American countries are developing fast their silk industries. Table 26.1 indicates country-wise production of mulberry silk.

TABLE 26.1

Countrywise Production of Mulberry Silk[1]

(tonnes)

Country	1960	1965	1966	1967	1968	1969	1970
Japan . . .	18,048	19,106	18,694	18,926	20,755	21,485	20,515
China . . .	7,000	6,860	7,180	7,770	8,450	9,030	10 200
USSR . . .	2,358	2,833	2,640	3,200	3,000	3,000	3,000
India . . .	1,154	1,634	1,502	1,668	1,745	1,758	2,258
Italy . . .	893	611	593	478	524	499	310
South Korea . .	470	849	1,154	1,329	1,687	2,403	2,846
others . . .	1,447	772	816	813	1,040	919	860
total . . .	31,370	32,665	32,579	34,184	37,201	39,094	39,989

1 Bulletins of the International Silk Association and Study Reports of the Central Silk Board.

26.1.7 There is no doubt that India can improve its position in the production of mulberry silk, which dominates the field of sericulture in the country. Many small and marginal farmers and artisans are engaged in the production of mulberry silk. The studies already made indicate the ways of improving the economies of silk production as an occupation. It was, therefore, thought fit to devote attention first to such problems of mulberry silk culture (moriculture) on which

action could be initiated immediately. Accordingly, an Interim Report on Sericulture was brought out by us in August, 1973. Salient features of the recommendations are :

(i) raising of mulberry crop with irrigation to maximum possible extent and introduction of bush type of mulberry crop in preference to mulberry trees in the univoltine areas like Jammu & Kashmir and Uttar Pradesh,

(ii) exploring chances of taking more than one brood of mulberry silkworm per year in the univoltine areas and introduction of bivoltine hybrids in Karnataka, West Bengal etc.,

(iii) improvement of local silkworms by cross breeding with exotic races wherever possible and specially replacing existing types of silkworms with good heat resistant strains in West Bengal, and

(iv) introduction of the system of supply of young worms (termed as chawkie) instead of eggs to rearers and encouraging the rearing of first two moults in special trays in order to improve survival (chawkie rearing).

Emphasis was also laid in the Report on a sound system of credit support for the farmers and cocoon rearers and on the system of functional cooperatives, to obtain finance from a single source for the entire chain of operations to be authorised from the agricultural credit wing of the Reserve Bank of India. Sericulture could be included as an additional item in the list of activities of the farmers' service society and the functional district organisation to be funded completely by a commercial bank, as already recommended by us in another Interim Report on Credit Services for Small and Marginal Farmers and Agricultural Labourers. We were concerned about the wide fluctuations in cocoon and raw silk prices affecting the stability and progress of sericulture industry in the country. We had noted the steps already initiated to establish a Raw Silk Price Stabilization Authority and the Central and State Raw Material Banks (Silk) in order to minimise price fluctuations. Prices are also linked with the quality of raw silk. Raw silk gets affected by the emergence of moths from cocoons. We recommended the development of proper methods and equipment for stiflling and the establishment of a chain of testing houses for determining the quality of raw silk.

26.1.8 Compared with mulberry, other kinds of silk are insignificant in the context of world production. In all of them, India holds a prominent position. *Muga* is an exclusive speciality of India. There are some casual references about eri silk production in some of the African countries; but all available information indicates that there does not seem to be any commercial production of eri silk in any

other part of the world. Ten per cent of the world's *tasar* production is from India, the rest is from China.

26.1.9 Production of different kinds of silk in different States of the country is given in Table 26.2. Of the total production of raw silk, mulberry, *tasar*, eri and *muga* account for 78, 12, 7 and 3 per cent respectively. The contribution of Karnataka in the production of mulberry silk is maximum, i.e. 82 per cent. West Bengal contributes 15 per cent, while Jammu & Kashmir a mere 2 per cent. While production in Jammu & Kashmir is not large, it has a historical significance. In India moriculture was first started in Kashmir in the medieval times from contacts with silk traders passing through that area on the caravan routes between China and Europe.

TABLE 26.2

Average Production of Raw Silk in various States of India (1969 to 1971)

(tonnes)

States	Mulberry		Tasar		Eri		Muga	
	production	percentage of all India	production	percentage of all India	production	percentage of all India	production	percentage of all India
1	2	3	4	5	6	7	8	9
Karnataka	1681	81.8						
West Bengal	302	14.7	7	2.2	5	2.8		
Jammu & Kashmir	47	2.3						
Assam	14	0.7			177	96.2	71	100.00
Uttar Pradesh	3	0.2						
Tamil Nadu	2	0.1						
Punjab and Haryana	2	0.1						
Himachal Pradesh	1							
Madhya Pradesh	1		137	43.8				
Manipur	1				1	0.5		
Maharashtra			1	0.3				
Bihar			154	49.2				
Orissa			13	4.2				
other States	2	0.1	1	0.3	1	0.5		
total	2056		313		184		71	
grand total of all kinds :		2624						
each kind as percentage of grand total		78.4		11.9		7.0		2.7

26.1.10 In the production of raw *tasar* silk, Madhya Pradesh and Bihar contribute 44 and 49 per cent respectively and the adjoining areas of West Bengal and Orissa 2 and 4 per cent respectively. Madhya Pradesh is essentially a consumer of *tasar* cocoons by virtue of the important weaving centres located in the districts of Bilaspur, Raigarh and Bastar. The weavers in Madhya Pradesh purchase cocoons and convert these into raw silk. Bastar used to produce some quantity, but that too has dwindled now. Ninety six per cent of eri silk production is in Assam region and 2 per cent in West Bengal. *Muga* production is wholly in Assam region.

26.1.11 The production of silk fabrics in the country in 1971 was 39 million sq metres, of which the quantity exported was only 4.5 million sq metres. The production for even internal consumption has been sustained till recently through tariff protection. The demand for protection arose in 1931-32 when severe competition from Chinese and Japanese silk almost crippled the economy of sericulture. The Government of India appointed in 1933 the first Tariff Board to go into the question of protection to silk industry. As a result, the silk industry has been under tariff protection since 1934. The tariff boards/ commissions undertook enquiries in the years 1934, 1938, 1948, 1951, 1953, 1958, 1963, 1969 and 1974. The present protection recommended in 1974 was for a period of five years, i.e. up to December, 1979.

26.1.12 The relative performance of India and Japan in moriculture is given below :

	India	Japan
(i) area of mulberry plantation required to produce 1 bale (60 kg) of raw silk (in hectares) . . .	3.10	0.57
(ii) quantity of silkworm seed in kg required to produce 1 bale of raw silk	1.21	0.13
(iii) yield of cocoons (green) in kg per box of silkworm seed, i.e. from 10 grams of eggs	12.28	28.40
(iv) renditta i.e. the quantity of green cocoons by weight required to yield a unit weight of reeled silk .	17	5

The performance of silkworms is poorer and the efficiency of mulberry leaves in the production of raw silk is also lower in India. In Karnataka, the major State for moriculture, about 80 per cent of mulberry area is under rainfed conditions and, therefore, the yield of leaves is as low as 3 tonnes per hectare. Under irrigated conditions, the yield can go up to 15 tonnes per hectare, which compares very favourably with Japan. However, Japanese leaves are far superior in

quality to Indian leaves. We have already recommended in our Interim Report that cultivation of mulberry under irrigation should replace rainfed cultivation in as large an area as possible. There is also need for better quality of mulberry leaves being produced through research.

26.1.13 In so far as organisational structure is concerned, Jammu & Kashmir, Karnataka and Assam have their full-fledged Departments of Sericulture. In Karnataka, the Director of Sericulture was looking after the sericultural development until 1966, starting from mulberry crop to marketing of cocoons as well as the Government Silk Filature Units, which were taken over from the Joint Stock Company (Mysore Silk Filatures Ltd.) in 1956. With the taking over of the Government Spun Silk Mills in 1966 from the Mysore Spun Silk Mills Ltd., a separate Directorate was set up to look after the silk industries, i.e. the factory organisation consisting of filatures, the Government Silk Weaving Factory and the Government Spun Silk Mills. Thus, at present there are 2 Directors, one for sericulture and the other for Government Silk Industries. Both of them function under a Minister of State for Sericulture. The State is divided into convenient zones for the purpose of administration, each under the charge of a Deputy Director. A network of silk farms, nurseries, grainages (egg producing centres for distribution), service centres and markets are functioning in each zone. The zones are divided into circles and each circle is placed under the charge of an Assistant Director. There are five Deputy Directors and 16 Assistant Directors, one Superintendent of Silk Conditioning & Testing House and one Principal for Sericultural Training School. One Deputy Director is exclusively placed in-charge of the cocoon markets, which are 45 in number. There is a Deputy Director stationed in Bangalore, who looks after the development schemes with 8 silk farms and one grainage in the developing areas of Belgaum and Dharwar. An exclusive area for indigenous and multivoltine silkworm seed has been set up in Karnataka. While for the preservation of exotic silkworm races, a rearing station has been established at high elevation together with a network of multiplication farms. The Government has organised grainages under its own control and also licensed seed preparers for ensuring cent per cent production of tested seed. The Department is running separate centres in order to popularise collective rearing of chawkie worms. The Department has set up mulberry nurseries and mulberry farms both for the purpose of supplying cuttings of improved varieties of mulberry and also to demonstrate different systems of mulberry farming.

26.1.14 In Jammu & Kashmir, there was a separate Department of Sericulture up to 1963. Then its control was transferred to the J&K Industries Corporation. Developmental activities suffered under this system and, therefore, there was another reorganisation in 1972, as a

result of which two distinct components have been created once again. These are : (a) the industrial aspect, which is looked after by the J&K Industries Corporation with a Managing Director at its head and (b) the proper sericultural aspect (insect and host development and management), for which there is a Sericulture Development Department. The latter consists of 4 Directors, one each for the two regions of Jammu and Kashmir separately, the third for *tasar* and a fourth for research, the third and fourth being jointly for the two regions. There are eight Deputy Directors and one Tasar Development Officer assisted by a sufficient number of Assistants, Inspectors and Operators to cater for the whole State. The Development Department takes care of mulberry trees and seed production. Since silk industry is a State monopoly, the Government undertakes to supply silkworm seed free of cost to the rearers and the rearers are also permitted to utilise mulberry leaves available on the trees which belong to the State Government. It is the Department's responsibility to undertake, encourage and plan planting of fresh mulberry seedlings every year. As an incentive, the Government pays the rearer a nominal sum for the upkeep of mulberry trees. The State has its own multiplication farms and grainages. Kashmir depends on exotic types of silkworm and, therefore, it has to import seed of the required races from time to time. The countries which supply seed are Japan, USSR, Italy and France. The seed multiplied by it in its own farms is not sufficient for distribution. The seed also loses its quality rapidly. Moreover, the available facilities and equipments are not adequate for attaining a high level of operational efficiency in the matter of industrial seed production. It would, therefore, be necessary to continue to import judiciously the seed material.

26.1.15 In Assam, most of the institutions and infrastructure built up during the earlier Plan periods have undergone considerable changes in view of the creation of Arunachal Pradesh, Nagaland, Mizoram and Meghalaya. The present organisation in Assam continues to be under the Directorate of Sericulture and Weaving. There is a Director, one Joint Director, one Research Officer, one Principal of the Training Institute at Titabar, two Deputy Directors and junior staff in the cadres of Superintendents, Managers, Inspectors and Demonstrators. The Department has its own sericulture farms, grainages, nurseries and chawkie rearing centres. The Department at present is only extending facilities for profitable utilisation of the nature-grown host plants of *muga* and eri. Its organisation for mulberry is on lines similar to Karnataka. Meghalaya has constituted a Directorate of Sericulture and Weaving. In Nagaland, Manipur and Tripura, sericulture constitutes a section under the Directorate of Cottage and Small Scale Industries. Sericulture usually forms a part of the Department of Industries in other parts of the country. In Orissa and Andhra Pradesh,

it falls under the Directorate of Handlooms and Textiles.

26.1.16 The developmental and industrial activities in respect of sericulture which go on in different States are guided and coordinated by the Central Silk Board. By and large, the activities of the Central Silk Board reviewed in the next section, reflect the progress of sericulture in India.

2 THE CENTRAL SILK BOARD

26.2.1 The silk industry in India was in a fairly prosperous condition prior to 1875. It suffered a steep decline thereafter for want of support against foreign competition. The first authentic enquiry into the conditions of silk industry was undertaken in 1914-15 by H. Maxwell-Lefroy, Imperial Silk Specialist and E. C. Ansorge. They observed that as the industry was scattered and un-organised producers were subjected to exploitation. It was suggested that a central organisation backed by the Government should attend to the needs of the industry. There was a slump in world trade in 1930 which also affected silk. This, combined with serious competition from China and Japan, severely hit the sericulture industry. As a result, tariff protection commenced from 1934. Thereafter, World War II gave a boost to it due to defence needs. Following the cessation of hostilities, the Government of India (Department of Industries and Supplies) appointed a Silk Panel in March, 1945 for making recommendations for the development of sericulture under a 15-year plan of industrial development for the whole country. This panel recommended the creation of an efficient organisation for enunciating and implementing definite policies on an all-India basis calculated to develop the industry. The Government of India accepted the recommendations of the Silk Panel in 1946 and piloted an Act in the Central Legislature in 1948. The Central Silk Board was set up in April, 1949 under the CSB Act LXI-1948. The Board coordinates the development of sericulture industry in various States. It advises the Government of India on policies governing export of silk goods and imports of raw silk and silkworm seed. It has the responsibility for pre-shipment inspection of silk goods exported from the country. The Board is also responsible for organising sericultural research, training and basic seed (egg) production.

Research Stations

26.2.2 Prior to 1958, Karnataka had one station at Channapatna and Bihar at Chaibasa. West Bengal did not have its own station, but

was utilising the services of the Berhampore Station, which was directly under the control of the Government of India. Assam had its station at Titabar. Kashmir did not have any research station of its own, perhaps because it mostly depended upon exotic seed material. Having realised the lacuna in the industry, the Government of India took a policy decision in 1953 to entrust the work relating to sericulture research to the Central Silk Board. In pursuance of the above decision, the research stations which were under the control of the State Governments were taken over by the Central Silk Board at different periods starting from 1961. At present, the following research and service stations function under the Board :

Research Stations :

(i) Central Sericultural Research & Training Institute, Mysore, (Karnataka).
(ii) Central Sericultural Research Station, Berhampore (West Bengal).
(iii) Central *Tasar* Research Station, Ranchi (Bihar).
(iv) Central *Muga* & Eri Research Station, Titabar (Assam).

Basic Seed Stations :

(i) Central Silkworm Seed Station, Pampore, (Jammu & Kashmir).
(ii) Silkworm Seed Station, Coonoor, (Tamil Nadu).
(iii) Central Tasar Silkworm Seed Station, Lakha (Madhya Pradesh).

A Univoltine Research Cell has been set up at Majra (Dehradun) in Uttar Pradesh recently, under the control of Pampore Seed Station. The research stations mentioned above conduct investigations on various facets, e.g. breeding, physiology, biochemistry and pathology of host plants as well as of worms. Studies on agronomy of host plants and on techniques of rearing worms are also conducted at these stations. The Board has also sponsored some researches on problems relating to processing of eri and *muga* fabrics at the Department of Chemical Technology, Bombay. The work of the research stations of the Board is organised and coordinated by its research coordinating committee which was constituted in 1961 with agricultural as well as sericultural scientists.

Main Research Achievements

26.2.3 It has been demonstrated that highly productive bivoltine

mulberry silkworms can be successfully produced now in Karnataka. These not only yield higher but also produce better quality of silk. The ratio of cocoons to raw silk in improved strains has come down to half (8-10 as compared to usual level of 16-20), meaning thereby that the yield standard has been doubled. The multivoltine local Karnataka hybrids have produced somewhat inferior quality of raw silk, viewed from international standards. But bivoltine hybrids produce internationally acceptable high grade silk, which is likely to increase exports.

26.2.4 The Central Sericultural Research and Training Institute, Mysore, has recommended for adoption the improved strain of mulberry, "Kanva-2", which gives more than 20 per cent increased yield over the existing varieties. In Berhampore, certain improved varieties which yield 50 to 80 per cent higher are under final selection. The lacuna in leaf quality has already been pointed out and it is hoped that this will be removed in future. Agronomical research on mulberry has shown that by proper manuring and soil moisture conservation, the average levels of mulberry yields could be easily doubled both in rain-fed and irrigated areas. In Jammu & Kashmir, where mulberry is raised as a tree, the methods of cultivation are far different from those in vogue either in Karnataka or in West Bengal. The Sericulture Department of this State has now undertaken to disseminate knowledge among silkworm rearers about the proper maintenance of mulberry trees by systematic pollarding and use of fertilisers during appropriate seasons. As a result of technical guidance offered by the Department and introduction of improved varieties of mulberry, it is anticipated that the yield of quality leaf would considerably improve in coming years.

26.2.5 Research work on *tasar* is done at the Central Tasar Research Station, Ranchi. Researches on eri and *muga* are undertaken at the Sericultural Research Station, Titabar, which came under the control of the Central Silk Board in April, 1972. The Titabar station has already drawn up plans for research and it is expected that useful results will emanate in due course. Insofar as *tasar* worm is concerned, there are heavy losses in the open from mortality due to unfavourable weather, diseases, parasites and predators. A rearer, therefore, hardly gets an effective yield of 10-20 per cent. Investigations at Ranchi showed that about 30 per cent loss occurs only during the first larval instar. The loss goes on decreasing subsequently with the advance of age when larvae develop capacity of self protection and proper grip. As the *tasar* worm likes natural conditions for growth, it was considered that it would in itself be a significant achievement if protective rearing could be done in the initial stage. Persistent efforts of the Tasar Research Station have established the possibility of con-

trolled rearing of newly hatched worms during the first 10 days or so and this results in an increase of about 40 per cent of cocoon yield over the traditional methods of complete outdoor rearing. This technique is being popularised in the traditional areas of Bihar, Orissa and adjoining parts. In order to make the new methods of rearing more effective, the Central Silk Board has been advocating natural and artificial regeneration of the conventional food plants in consolidated blocks. This work is required to be included by the Forest Departments of the concerned States in their programmes.

26.2.6 It is well known that *tasar* produced on oak is better than that produced on other trees as found in the traditional *tasar* producing areas of this country. Because of this reason, the Indian *tasar* could never compete with the technologically superior Chinese *tasar*, the latter being obtained from rearings on oak. A survey conducted by the Tasar Station in 1965 revealed the presence of an indigenous silkworm variety (*A. roylei*) on oak trees in Jammu & Kashmir. An interspecific hybrid between this new variety and *A. pernyi* of Chinese origin has now been successfully synthesised and named *A. proylai*. This new hybrid thrives well on oak and produces *tasar* of high quality. It is also amenable to domestication. The development of this *tasar* hybrid has opened up a new vista of opportunities for extending *tasar* cultivation in the entire oak belt which extends from Manipur in the east to Jammu & Kashmir in the west along the Himalayas. The total area of this oak belt is estimated to be about 800,000 ha. Total silk production in the country is of the order of 30 crores of rupees, which includes about 4 crores from *tasar* silk. It is claimed that oak forests of the entire sub-Himalayan belt have a potential to produce *tasar* silk worth about 300 crores of rupees and this is required to be exploited to maximum possible extent. On the basis of recent successful field trials by the Ranchi Tasar Station in Manipur, Assam, Uttar Pradesh, Himachal Pradesh and Jammu & Kashmir, the Government of India has already set up research sub-stations for oak *tasar* culture at Imphal (Manipur), Ranikhet (Uttar Pradesh) and Batote (Jammu & Kashmir) in late 1970. The setting up of a sub-station in Himachal Pradesh has already been approved. The sub-stations are entrusted with the task of propagating *tasar* culture in their respective zones by carrying out field trials and community rearing in close coordination with villagers and the State Governments concerned. A project costing Rs. 8 crores to exploit the oak forests of Manipur in the next few years has already been launched by the Central Silk Board and similar projects are underway for the States of Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh and Assam.

26.2.7 Having felt the inadequacy of suitable technical personnel in the States concerned with sericulture, the Board set up under its

control an all-India Sericultural Training Institute, Mysore, in October, 1958. The Institute was imparting training in two courses (one senior and the other junior) to candidates deputed by the States until July, 1966. Subsequently, the pattern of work of the Institute was reorganised by integrating training with the research activities and, therefore, it has been merged with the Board's Central Sericultural Research Institute, the combined institute being designated as the Central Sericultural Research & Training Institute. The junior course of the Institute was stopped and was left to the training schools organised in the States. Schools for the purpose exist in the States of Jammu & Kashmir, Assam, Bihar, Karnataka and West Bengal. The senior course training imparted prior to reorganisation is being continued since July 1, 1966 with certain modification in the curriculum. The Central Institute at Mysore now offers a postgraduate course of 15 months' duration in moriculture. It is also conducting a refresher course of 6 weeks' duration for the benefit of in-service officers of sericulture departments of various States. A training institute for non-mulberry silks is being established at the Central Tasar Research Station at Ranchi. This Station at present offers a refresher course of 4 weeks to in-service officers on *tasar*.

Other Institutions

26.2.8 There are various other kinds of institutions functioning under different State Governments, which have come up as a result of the promotional measures of the Central Silk Board. The varied nature of fields of work and increase in the number of various institutions may be seen in Table 26.3.

Chawkie Rearing

26.2.9 In the methods of silkworm rearing, the most advantageous and economical technique is the system of institutional rearing of young silkworms (chawkie) from the egg stage and supplying young worms to individual rearers rather than eggs. The collective system of incubation and rearing reduces mortality, inherent in an individual's solitary efforts. Further, it has an advantage of saving labour of an individual rearer to the extent of about 10 days (time involved in total rearing from egg stage being about a month). Although precise data on assessing the impact of such rearings on farmers' fields on a large scale have not been collected, it is estimated that under the conditions of irrigated gardens in Karnataka, if a farmer harvests 5 crops, rearing 3,750 layings per annum per ha, the improvement in cocoon yield will be of the order of 250 kg. In terms of money value, this increase will

TABLE 26.3

Progress of Sericultural Institutions

Institutions	1950-51	1965-66	1971-72
mulberry			
hill stations for silkworm rearing	3	8	8
mulberry nurseries	45	124	124
seed farms	36	65	68
multiplication farms and demonstration centres	18	66	70
government grainages (egg producing centres)	31	80	118
licensed seed preparers and aided grainages	184	540	620
chawkie (young worm rearing) centres	nil	185	185
incubation centres	nil	380	340
cooperatives	7	68	113
markets	1	70	116
training centres	2	7	7
tasar			
seed supply stations & sub-stations	7	78	93
demonstration farms	nil	35	35
training centres	1	2	2
cooperatives	nil	68	99
markets	nil	14	10
research units	nil	3	2
muga			
seed farms	3	9	9
propaganda out-posts	nil	2	2
cooperatives	nil	9	9
aided grainages	nil	142	162
eri			
seed station	10	23	34
demonstration centres	10	67	67
cooperatives	nil	25	25
research units	nil	2	2
markets	nil	1	1
aided grainages	nil	100	86
total	358	2,173	2,407

mean an additional income of Rs. 5,000 per ha per year at the current rate of Rs. 20 per kg of cocoons. In terms of cocoon yield per 100 Dfls, the increase works out to be 7 kg. Assuming an average yield of cocoons per 100 Dfls to be 25 kg in the traditional method of rearing, this means an increase of 28 per cent under field conditions. The number of chawkie units in the States has increased from 25 in 1960 to 185 in 1971.

Sericultural Cooperatives

26.2.10 Large scale operations of mulberry farming and silkworm rearing are facilitated through cooperative endeavour. A number of labour saving devices can be successfully employed by these institutions to improve quality and also to increase productivity. The rapid strides registered by Japan in the development of its silk industry after World War II are mainly due to cooperative institutions. The Central Silk Board, therefore, took initiative and examined the possibilities of organising sericultural cooperatives. It constituted a Special Committee for the purpose in 1956. The Committee examined all aspects and suggested a gradual adoption of the system. The number of sericultural cooperative societies as on the 31st December, 1972 stood at 196 (mulberry 98, *tasar* 65, eri 22, *muga* 11). The types of cooperative societies organised mainly pertain to seed production, chawkie units, credit and service, cocoon and raw silk marketing, and multipurpose. The number of chawkie units in cooperative sector is 40. Progress of cooperatives is reviewed by the Central Silk Board from time to time.

Improvement Schemes

26.2.11 Karnataka has 94,350 hectares under mulberry cultivation, of which only 21,600 hectares are irrigated. There is considerable potential in the State for large scale expansion of the industry not only by bringing new areas under mulberry but also by improving the productivity of existing plantations, providing necessary irrigation facilities and high quality seed and employing improved techniques of rearing. Keeping in view these possibilities, the Government of Karnataka formulated in May, 1970 a Rs. 102 crore crash programme for development of sericulture industry in the State over a period of 10 years in consultation with the Central Silk Board. The programme was subsequently revised in September, 1970, reducing the total outlay to Rs. 80 crores. The programme envisages replacement of existing mulberry with new high yielding varieties, provision of irrigation facilities to the mulberry plantations in the rainfed areas, and financial assistance for construction of rearing houses and grainages and reeling sheds etc.

A production target of 3,500 tonnes per annum is estimated to be achieved by the end of 10 years, as against the current production of 1,800 tonnes. The financial requirement of the programme will be met in the form of loans from nationalised banks. The loans will be made available by the banks directly to the sericulturists at the normal rate of interest. Interest amounting to 3 per cent of the loan will be subsidised by the State Government and the Central Government on 50:50 basis. This subsidy will be granted only for the first two years. The State Bank of Mysore and the Canara Bank have come forward to finance the above project. Though the main elements of the programme were approved by the Ministry of Industrial Development in November, 1971, it came into operation only in 1973 because of some initial delay in finalising the working plan. The State Government has appointed a special officer of the status of Joint Director of Sericulture to be exclusively incharge of the programme.

Market Stabilisation

26.2.12 There are wide price fluctuations in sericulture industry for a variety of reasons. Raw silk/silk fabrics being considered luxury items could not be brought at par with other agricultural crops under the system of regulated markets. Instability of cocoon crops and wide variations in the quality of cocoons harvested, seriously affect market trends. Absence of standardisation, quality control and, above all, the absence of an efficient marketing organisation have added to the difficulty of the problem. Cocoons are purchased by dealers on an open auction system on a visual examination of lots. Prices do not usually go by quality. The Price Stabilisation Committee of the Board, which studied in depth the question relating to the wide fluctuations in prices of mulberry silk cocoons and raw silk, has pinpointed the absolute necessity for stabilisation of silk markets to ensure progressive development of the industry. The Committee has made the following suggestions for achieving a measure of stability in the silk markets :—

- (i) stabilisation of cocoon crops with reference to quality as well as quantity.
- (ii) proper balancing of exports, production and prices;
- (iii) maintenance of tempo of demand (both domestic and export) by adopting a suitable marketing strategy and through effective publicity programme;
- (iv) well-equipped cocoon testing houses in all the concerned States;
- (v) fixing an all-India norm so that the sericulturists all over India get assured of a minimum economic price for their produce duly linked to its quality;

(vi) rational marketing arrangement for cocoons and raw silk, standardisation and grading of the products (besides fixation of floor and ceiling prices); and

(vii) setting up, as a first step in this direction a central raw silk price stabilisation authority to advise the Central Silk Board in the formulation and implementation of policies governing price stabilisation and for ensuring effective coordination of achieving the stability in the silk markets throughout the country.

26.2.13 The Board has already constituted a Raw Silk Price Stabilisation Authority comprising the representatives of the Governments of Karnataka, Jammu & Kashmir and West Bengal, the Director (Khadi Silk) of the Khadi & Village Industries Commission and the President of the Karnataka State Silk Marketing Cooperative Society. The above Authority is headed by the Chairman of the Board with the Secretary of the Board as its Member-Secretary. The functions assigned to this Authority are broadly as under :—

(i) to maintain a constant watch on the cocoon and raw silk markets in the country;

(ii) to advise the Board with regard to formulation and implementation of policies/schemes relating to stabilisation of prices of mulberry cocoons and raw silk;

(iii) to coordinate the activities of the regional/state-level organisations set up for the purpose; and

(iv) to undertake such other activities as may be necessary for bringing out stability in the silk markets in the country.

Although the above Authority has been constituted at present for mulberry silk sector, this can cover all kinds of silk and related sericultural products. While this Authority could function as an apex body, individual corporations for mulberry and non-mulberry sectors could be set up separately for speedy implementation of the policies and programmes chalked out by it. This would be analogous to the working of the price stabilisation mechanism functioning in Japan.

26.2.14 Apart from making specific recommendations of long term nature for ensuring stabilised progress of the industry, the Price Stabilisation Committee has recommended a scheme for stabilisation of raw silk prices in the country under the existing conditions. The scheme provides for a central raw material bank for procurement of raw silk, building up of a buffer stock and regulation of market mechanism through judicious purchases and well-timed releases. The Board has already initiated measures in this direction with the establishment of a Raw Material Bank for *tasar* cocoons and *tasar* waste in August, 1972. This is done on a pilot basis and on the basis of its achievements the scheme will be extended to other areas.

Testing and Grading of Raw Silk

26.2.15 The Indian Standards Institution (ISI) has formulated standards for testing and grading of Indian raw silk in consultation with the Central Silk Board. There are three raw silk conditioning and testing houses, one each at Srinagar, Bangalore and Calcutta, where testing of raw silk is undertaken on voluntary basis according to standards prescribed by the ISI. Besides, there are facilities for testing of raw silk at the filatures in Karnataka and Jammu & Kashmir. The Central Silk Board has been urging the State Governments to introduce compulsory testing and grading of silk produced in the States. The recommendation of the Board is under active consideration of the State Governments.

Preshipment Inspection

26.2.16 Preshipment quality inspection of mulberry silk fabrics was made compulsory under the erstwhile export promotion scheme for mulberry silk fabrics introduced in 1958. Preshipment inspection for *tasar* fabrics was introduced in 1963. The Central Silk Board has established certification centres at Bombay, Calcutta, Delhi, Madras, Varanasi, Bangalore, Srinagar and Bhagalpur.

CENTROSILK Certification Trade Mark

26.2.17 A scheme for inspection and stamping of natural silk fabrics with 'CENTROSILK' Trade Mark was also introduced by the Central Silk Board with effect from January 2, 1965. The object of the scheme is to prevent the sale of 'non-silk' fabrics particularly rayon fabrics as 'silk' fabrics by unscrupulous traders and thus to safeguard the interests of consumers as well as producers of pure silk fabrics and to promote exports. The scheme is at present operating on a voluntary basis.

Prospects of Sericulture

26.2.18 India occupies a minor position in world's mulberry silk production. India's export of mulberry silk fabrics is only one-eighth of its internal production and is almost insignificant in the world supply. Whatever is exported from the country is not because of quality considerations but because of the artistry of finished products. Moreover, had it not been for tariff protection, the prospects of the existing silk industry would have been very bleak indeed. The present high cost of foreign raw silk may give a fillip to internal production,

but this should not lead to a false sense of self-sufficiency which is assured only by increased production. One has to recognise the fact that low productivity and poor quality cut at the very root of silk industry. The Central Silk Board has been making efforts for improvement. Some of the State Governments having their own organisations for sericulture are also taking steps for effecting improvement. Even then no increase in production and improvement of quality of silk are noticeable. This seems to be the crux of the problem of Indian sericulture.

26.2.19 We feel that there is scope for extending sericulture to new areas within the country. This alone can increase production to such levels as can make the industry self-sustaining. Extension of area will automatically throw open opportunities of gainful employment to the rural population. This will have its own advantage in marginal areas, where other agricultural activities by themselves are not very rewarding at present. A basic problem, on the solution of which hinges sericultural production, is the supply of silkworm seed. It has not only to be produced in large quantity but requires an effective organisation to maintain its quality.

26.2.20 The intention at present is to avoid duplication in our consideration of matters which are already engaging the attention of the Central Silk Board. The Board has organised activities on many aspects of research and development of the industry and has plans for the future. It has tried to remove many of the marketing difficulties through the Central Price Stabilisation Authority and Raw Material Banks. Only one major problem remains in the marketing field that is the introduction of quality control in cocoon transactions. It is only in West Bengal that a rational pricing system operates at present, whereby prices are related to the quantity of cocoon required to yield one kg of raw silk. This is on the lines of the Japanese 'Kakeme' system. Due regard to quality is not being paid elsewhere and the rearers of cocoons are the sufferers. This deficiency is equally noticeable in *tasar,* eri and *muga* transactions. There is need for a system similar to that prevalent in West Bengal or Japan to be operated throughout the country by the cocoon testing stations. It is hoped that this improvement would be included in the Central Silk Board's schemes of price stabilisation and raw material banks.

26.2.21 In the light of the above analysis, the major problems which remain to be considered are :

(i) extension of sericulture to new areas;
(ii) multiplication and distribution of silkworm seed; and
(iii) future organisational changes in the States as well as at the Centre.

These are briefly discussed in the succeeding sections.

3 EXTENDING SERICULTURE TO NEW AREAS

26.3.1 The case of *tasar* culture to be extended along the entire sub-Himalayan oak belt has already been discussed in the previous section. The need for and prospects of extending other kinds of silk are examined below separately.

Moriculture

26.3.2 Climatologically, moriculture is being practised under diverse conditions. Kashmir is temperate. West Bengal is warm and humid, whereas Karnataka is warm and comparatively dry. In so far as mulberry plant is concerned, its natural plantations are found in tree form in the hilly regions and it is generally cultivated as a bush crop in the plains. The existing distribution of area under mulberry crop, bush form as well as the number of trees, wherever they exist, are shown in Table 26.4 for the different parts of the country. It seems that cultivation of mulberry should not present a problem wherever there is either assured rainfall or wherever irrigation facilities could be provided. However, it would be better if feasibility trials are conducted in order to locate areas where mulberry cultivation can be undertaken with success. Once the areas of successful cultivation of mulberry have been located it will then be necessary to take up studies on the successful rearing of mulberry silkworm in those areas. If moriculture has to be introduced on a large scale, it will be necessary to take many broods of mulberry silkworm in a year. It is likely that hot months may prove to be uncongenial for the worm in many parts of the country, but this difficulty can be obviated by providing airconditioned rearing houses. An uninterrupted flow of electricity is very necessary for the continuous functioning of airconditioned houses. Stoppages can prove fatal for the worms. However, this handicap can be surmounted by providing a generator to every airconditioned rearing house. The entire venture in that case may be far from remunerative. But in order to help the expansion of a promising industry, the State Governments concerned should come forward with the needed assistance.

26.3.3 Taking note of the outcome of the experimentation as suggested above, consideration may be given to extend moriculture throughout the length and breadth of the country. The principle which should limit the extension of moriculture is that it should not unnecessarily encroach upon other kinds of sericulture in their producing areas. However, if certain pockets in these States could be profitably developed for moriculture, extension of moriculture may be allowed. Moriculture already exists in Jammu & Kashmir, West

Bengal and Karnataka. Other States where extension/introduction of moriculture can be considered are Himachal Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Tamil Nadu and Kerala.

TABLE 26.4

State-wise Area under Mulberry and Number of Trees (as in 1971)

State	Area under mulberry (ha)	Number of trees (thousand)
Karnataka	94,349	26
West Bengal	5,380	80
Jammu & Kashmir	..	2,400
Tamil Nadu	2,896	3
Andhra Pradesh	644	..
Assam	600	500
Manipur	360	270
Uttar Pradesh	246	149
Himachal Pradesh	120	47
Bihar	111	2
Madhya Pradesh	100	..
Punjab	76	120
Tripura	3	1
total	104,885	3,598

26.3.4 We have already recommended in our Interim Report[1] on Sericulture the extension of moriculture to some additional districts of Jammu & Kashmir, Uttar Pradesh, Madhya Pradesh, West

1 Hereafter referred to as Interim Report.

Bengal, Karnataka and Tamil Nadu. The list of existing and proposed districts is reproduced below :

Existing districts	Potential districts
(i) Jammu & Kashmir	
Jammu	Punch
Srinagar	Doda
Anantnag	
Baramula	
Udhampur	
Kathua	
(ii) Uttar Pradesh	
Dehra Dun	Almora
Saharanpur	Nainital
Etawah	Tehri Garhwal
(iii) Madhya Pradesh	
Indore	Sehore
Dhar	Dewas
(iv) West Bengal	
Malda	Bankura
Murshidabad	Purulia
	Birbhum
	West Dinajpur
	Darjeeling
(v) Karnataka	
Kolar	Belgaum
Bangalore	Dharwar
Tumkur	Shimoga
Mandya	Hassan
Mysore	
(vi) Tamil Nadu	
Nilgiris	Coimbatore
	North Arcot
	Tirunelveli

Ericulture

26.3.5 Eri silk holds promise for blending with man-made fibres, because it is a good material for both mill as well as handspun yarns. The silk spinning mills all over the world are suffering from acute shortage of natural spinning fibre. Eri silk is likely to fill this gap. There is another advantage with eri silk. Unlike other silk cocoons, moths are not killed but are allowed to emerge out of them. Because of this eri silk finds favour in Tibet and Bhutan. Some other countries may prefer this kind of silk. As mentioned in Chapter 22 on Commercial Crops, in India, castor crop is grown to a major extent in Andhra Pradesh (69%). Other castor growing States are : Gujarat (11%), Orissa (5%), Karnataka (8%) and Tamil Nadu (2%). Ericulture is concentrated almost entirely in Assam, which produces 97 per cent of eri silk. Assam does not cultivate much of castor. It is found wild and is used for the purpose of rearing castor worm. It is desirable to investigate why ericulture did not catch up in the major castor producing States.

26.3.6 It is known that the yield of seed goes down if castor leaves are plucked in large numbers. Removal of 25—30 per cent leaves for feeding worms reduces yield by about 35 per cent. However, it is not difficult to breed dual purpose varieties, or develop agronomic practices (e.g. plant density), which can give a satisfactory yield both of seeds as well as leaves. Secondly, Japan is known to have perfected an artificial diet using castor leaf powder as one of the ingredients and the technique is found to be commercially feasible. Development of such artificial powder can reduce the consumption of leaves and lesser dependence on leaves may not prove harmful from the point of view of seed yield. If the rearing of eri worm under drier conditions proves a limiting factor in some States, recourse can always be taken to rearing in air-conditioned houses, as has already been suggested in the case of mulberry silkworm. It is desirable to study what technological accomplishments can make ericulture a paying proposition in the major castor growing States. Castor is a minor crop in the States of Uttar Pradesh, Madhya Pradesh, Bihar, Punjab, Haryana, Rajasthan and Maharashtra. It is also commonly grown in isolated patches near homesteads, footpaths, bunds, channels and wells in these States. If ericulture could be developed in these minor castor growing States as a profession, it will prove helpful for the rural folks to utilise their leisure or lean periods gainfully. Thus, the possibilities of extension of ericulture could profitably be explored in Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu.

Muga Culture

26.3.7 *Muga* silk yarn is used extensively in the production of traditional *saris* and *mekhalas*, but of late its handspun yarn has found an extensive use in the production of heavy dress material in combination with other natural silk fibres. It is a versatile fibre and, therefore, yarn blended with it will find an increasing demand in the coming years even in exportable fabrics. The Brahmaputra valley of Assam constitutes the typical *muga* zone, especially the districts of Lakhimpur, Dibrugarh, Sibsagar and South Kamrup. There is need to explore the possibility of its extension in other States of the north-eastern region. The west coast comprising Kerala, coastal Karnataka, Goa and Konkan is somewhat similar to Assam conditions in so far as rainfall is concerned. It is worthwhile to examine whether *muga* can be introduced into this belt also.

26.3.8 Agricultural universities in these areas may be involved in research work for the extension of sericulture to new areas. Coordinated programmes may be drawn up by the Central Silk Board and its research stations in consultation with the universities.

26.3.9 The Central Silk Board has estimated the future production of raw silk as indicated below :

(tonnes)

Year	Mulberry	*Tasar*	Eri	*Muga*	Total
1974-75	2,450	470	215	85	3,220
1979-80	3,675	650	375	125	4,825
1984-85	5,500	975	505	150	7,130
1989-90	8,250	1,300	625	160	10,335
1994-95	11,000	1,625	775	170	13,570
1999-2000 . . .	13,750	1,930	930	180	16,790

According to this estimate, production is likely to increase 5 fold between 1974-75 and 2000 AD. The employment potential is estimated to increase from 3.5 to 10 million man days. These estimates are likely to undergo major changes when sericulture is extended to new areas indicated above.

4 MULTIPLICATION AND DISTRIBUTION OF SILKWORM SEED

26.4.1 So far more attention has been devoted to organised seed production and multiplication in a scientific manner in mulberry silkworm than in other kinds. This is partly due to larger spread of moriculture and partly due to special handicaps, which have been

experienced in other cases. *Tasar* and *muga* worms have presented difficulties in indoor rearing. Therefore, it has been only possible to get better quality cocoons from natural collections and use them for raising new progenies. Some governmental seed farms for these two kinds of worms have existed in the concerned States for distribution of seed or seed cocoons. The handicap in the case of eriworm has been lack of adequate genetic research, but even then some governmental grainages did function for it in Assam. With the domestication of worms and evolution of their new varieties and hybrids, ample scope will arise in due course to organise a system of multiplication and distribution of seed in *tasar*, eri and *muga* worms.

26.4.2 Mulberry silkworm seed is multiplied in four stages. Once a race has been established and released by a research organisation, its males and females are to be maintained and supplied perpetually for further multiplication. This is the first stage. The next three stages constitute merely the three succeeding steps to multiply seed in larger and larger numbers through the males and females obtained from the preceding stage in every case. Eggs derived at the end of the fourth multiplication stage constitute the material for distribution among the silkworm rearers. Therefore, the seed of the fourth stage is called the Industrial Seed. The eggs produced for this stage are duly examined and are distributed in units of 100 Dfl in the case of multivoltine worms or ounces in the case of univoltine worms. The place where the fourth stage is multiplied and eggs suitably rendered in packs for distribution is known as a grainage. In genetics, the first stage is known as P3, denoting the multiplication of great grand parents. The second stage is known as P2, denoting the multiplication of grand parents and the third stage is known as P1, denoting the multiplication of parents. Fourth stage is called Pl, denoting the Industrial Seed. The Industrial Seed in use now-a-days both in the uni-and multivoltine areas is generally a hybrid (F1). In some cases, the Industrial Seed may also be of pure race. The use of hybrids is to stabilise cocoon crops and standardise the quality of cocoons through exploitation of hybrid vigour. For hybridization purposes, pure races of indigenous as well as exotic parent materials have to be maintained separately in such a manner that intermingling is avoided. For this purpose, basic seed zones for indigenous and foreign races are set up exclusively away from industrial rearing zones.

26.4.3 The stock of P3 seed of mulberry silkworms is maintained by the Central Silkworm Seed Station at Pampore (Srinagar), which is directly under the control of the Central Silk Board. It is then supplied to the regional P2 stations, which are run by the concerned States. In many such States, P2 and P1 stations and other seed multiplication farms are functioning. However, in the States where

the seed organisation is still in its infancy, the Central Silkworm Seed Station, Pampore, makes necessary supplies, e.g. P2 seed to Jammu & Kashmir and P1 seed to Punjab and Himachal Pradesh. For the same purpose, an integrated scheme for the multiplication of basic seed, formulated in consultation with the States of Jammu & Kashmir, Karnataka, West Bengal and Tamil Nadu is also in operation. According to this scheme, the Central Silkworm Seed Station supplies P3 stock to the following zonal stations for multiplication of P2 stock :

(i) Basic Seed Station, Mirgund (Jammu & Kashmir)
(ii) Basic Seed Station, B.R. Hills (Karnataka)
(iii) Hill Nurseries, Kalimpong (West Bengal)
(iv) Silkworm Seed Station, Coonoor (Tamil Nadu)

26.4.4 P1 stock is multiplied at the Government Seed multiplication farms as well as by private seed preparers, who have to get licence for the purpose from the Government. Similarly, the stock of F1 stage is also either produced at the Government grainages or by certified industrial egg producers. Karnataka and West Bengal are the two States where a system of licensed seed preparers is in operation. Men in the job are given additional training and facilities for producing industrial seed under departmental supervision. Necessary infrastructure in these States has been built up in this regard. In almost all other States like Jammu & Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Assam, Meghalaya, seed production is entirely controlled by Governments concerned.

26.4.5 The system of seed multiplication and distribution is better organised in Karnataka than other States. There are (a) five basic seed farms, 2,000 ha of exclusive seed zone and 8,000 selected seed rearers for pure local race and (b) seventeen seed farms and 8 nurseries, 2,500 ha of exclusive seed zone and 1,750 selected seed rearers for foreign race. Similar arrangements also exist in other multivoltine areas like West Bengal, Tamil Nadu, Andhra Pradesh and Madhya Pradesh on a scale proportionate to the mulberry cocoon production. In the univoltine areas covering Jammu & Kashmir, Punjab, Himachal Pradesh and Uttar Pradesh, there is no change in the basic pattern of seed organisation. The scope for effective utilisation of the numerous technical staff is limited as only one crop is harvested in a year. The situation in Uttar Pradesh is particularly difficult. If the capacity of the seed organisation in Uttar Pradesh is to be fully utilised, there should be a regular off-take of the surplus seed in the neighbouring States. As the Central Silk Board had a programme to increase the production of bivoltine raw silk to the level of 800 tonnes during the course of 5 to 6 years from the year of its implementation, an integrated approach for the production and distribution of uni-

and bivoltine silkworm seed on an all-India basis is expected to be evolved. Moreover, as extension of moriculture to new areas is being proposed, there will be no difficulty in absorbing surplus seed produced in any particular State.

26.4.6 The question of seed production and multiplication has to be considered carefully as a pre-requisite to sericulture on a very large scale. A system has to be evolved which will be applicable to all silkworms on a uniform basis throughout the country. P3 seed is being produced and distributed by the Central Silk Board in the case of mulberry worm. P2 seed is either produced by the Central Silk Board or the State Governments. P1 and F1 seeds are produced by the Governments and private parties. The responsibilities between various agencies are not precisely demarcated. Therefore, the system needs some modifications. It is suggested that the production of P3 seed should be in the direct charge of the Central Silk Board. State Governments should be responsible for P2 stage, whereas P1 and F1 stages should be left to be dealt with in the private and cooperative sectors. Coordination of the work of various agencies should be the responsibility of the Central Silk Board. In this manner, the ultimate overall responsibility of planning and organising multiplication and distribution of silkworm seed will also be that of the Central Board.

26.4.7 Silkworm Seed Acts are in force in Karnataka, Tamil Nadu and Punjab. These Acts prohibit the use of un-examined seed. Himachal Pradesh and Andhra Pradesh are also taking steps to introduce necessary legislation in this regard. Wherever seed production is entirely in departmental hands, the absence of an Act may not prove to be a handicap, because governmental control generally ensures quality. However, the situation changes when private seed preparers begin to operate. It is necessary to have a composite Central Silkworms Seed Act applicable to all the States in order to meet future exigencies on a common basis.

26.4.8 In so far as certification of seed prior to its being supplied to cocoon rearers is concerned, the testing of moths and certification are generally done at present by the departments themselves. This is being done in Karnataka, because of which the standard of production there is better than in many other States. In future, every State should have a certification agency distinct from the production set up. This agency should deal with all the four kinds of silkworms. The State certification agencies should work under a Central certification wing which should be created within the Central Silk Board for this purpose.

26.4.9 The supply of young silkworms (Chawkie) after the 2nd instar to rearers, instead of seed in the form of grains in box or sheet is universally accepted as positively beneficial. It is already being

popularised in mulberry silkworms, although the progress is slow. Indoor rearing of *tasarworm* up to the 2nd instar has also passed experimental stage and is being advocated for adoption on a mass scale in the traditional *tasar* growing areas. The method of chawkie rearing has to be popularised in all the four kinds of silkworm. For this purpose, it will be necessary to add one more stage at the end of stage 4, i.e., F1 certified industrial seed, to be called stage 5 dealing with chawkie rearing and supply. Just like P1 and F1 stages, chawkie rearing should be left to private and cooperative sectors, but to begin with a good lot of governmental control and advice will become necessary. A system of certification for chawkies will have to be developed and executed by the usual certification agency. The ultimate object should be to replace the system of egg supply to commercial cocoon rearers by certified healthy young worms. The envisaged Central Act should eventually include chawkie rearing, the Act itself being called the Central Silkworms Seed and Chawkie Act.

5 ORGANISATIONAL STRUCTURE

26.5.1 Silkworm is in the realm of entomology. The cultivated crop plants of mulberry and castor require the application of the science of agronomy, while forest trees which act as host plants to silkworms require the application of horticulture and forestry. In sericulture, therefore, a chain of close-knit activities starting from the raising of host plants to the rearing of worms and leading to cocoon production, should firmly connect the farmer and rearer with the entomologist, breeder, agronomist, horticulturist and silviculturist. Agricultural Departments have a direct involvement in sericulture in many countries. In Japan, the Ministry of Agriculture & Forestry controls the entire industry through a Raw Silk and Horticulture Bureau. In the Soviet Union, sericultural operations starting from raising mulberry plants to the production and drying of cocoons are looked after by the Ministry of Agriculture. The reeling of raw silk and manufacture of fabrics come under the Ministry of Light Industries. The rapid progress of silk industry in South Korea is due to joint efforts made by the Ministry of Agriculture & Forestry and the Sericultural Association.

26.5.2 Sericulture in India has been attached to the Department of Industries at the State level. The Central Silk Board, which was under the Ministry of Foreign Trade earlier, is now under the Ministry of Industrial Development. The members of the Central Silk Board are all drawn from the Government Departments of Industries or private industrial interests. The organisational structure in different

States of the country is of two types, viz., (a) where independent departments exist for this subject, e.g. Karnataka, Jammu & Kashmir and Assam and (b) where the subject forms just a section within the industries or some other allied department. In this set up, the emphasis has throughout been mainly on the industrial or trade aspects of sericulture. Whatever improvement work on silkworms or their food plants has been attempted has been without the full involvement of agricultural organisations. As a result the silk industry has never been able to stand on its own and rapid progress will not be achieved unless there is a change in the position. All operations upto the production and processing of cocoons can be undoubtedly placed under the Department of Agriculture. In reeling there are two ways, viz., either the poor rearers themselves do this job as a cottage industry or some industrial fabric manufacturing concern undertakes the operation. Because of this special situation, when reeling is done by rearers themselves, it should be considered to fall within the purview of agriculture so that all benefits to small rearers can accrue from one and the same source, but otherwise, this operation should fall within the industrial sector. It has been stated that as the Agricultural Department and related organisations are fully occupied, they should not be burdened with the development of sericulture.

26.5.3 We strongly feel that the subject of sericulture upto the reeling stage wherever reeling work is done by rearers themselves or otherwise upto the cocoon stage should come under the purview of the Department of Agriculture. The remaining operational aspects, which are industrial in nature, should be looked after by the Industries Department. Such distribution of responsibilities should be applicable to all States in order to bring about uniformity in the pattern of set up throughout the country. Accordingly, the existing set up in every State, including Jammu & Kashmir, Karnataka and Assam will have to be revised and suitably adjusted between the Department of Agriculture and Industries. It is implied in this that each of these departments will build up suitable staff cadres to cope adequately with the extent of sericultural activity which is likely to develop in their State. At the Centre, the Central Silk Board should be attached to the Ministry of Agriculture and Irrigation. The composition of the Board also needs a change. It may have representatives from the States, the ICAR, the Union Ministries of Agriculture & Irrigation, Industrial Development and Commerce, All-India Khadi and Village Industries Commission and all-India Associations, if any, concerning sericulture seed business, private farmers and rearers and silk industry. There may be a smaller executive panel in the Central Board, which would be called upon to find ways and means to implement Board's decisions. The status of Board's Secretary should be such that he should be able

to take direct decisions. It will be an advantage if he is a qualified technical person. He should have a rank equivalent to a Joint Secretary in the Government of India. In so far as the finances of the Board are concerned, there is already a provision in the Central Silk Board Act 1948 for the levy of cess on raw silk. In practice, however, such a cess was not levied so far because of the poor state of the industry. But as soon as the industry shows signs of progress and becomes viable, the cess can be levied.

26.5.4 While the institutions under the Board and their programmes may continue as before, the ICAR together with its institutions and agricultural universities have to be drawn in more and more in future research activities. The Forest Research Institute, Dehradun, has to be involved in the silvicultural problems. The areas and extent of cooperation from these organisations may be decided upon by the Central Silk Board through periodic mutual discussions. In view of the technological gap in the fabrication of equipments for sericulture, researches on fibre and utilization of by-products etc., it is suggested that a Central sericulture technological research laboratory may be set up.

26.5.5 There is also the problem of obtaining trained persons in sericulture in sufficient numbers. For higher types of jobs, agricultural universities will have to introduce courses at the graduate and post-graduate levels. The universities will have to involve themselves increasingly in research and extension activities. Therefore, a sericulture unit will have to be opened in every agricultural university. It may take the form of a full-fledged division in major sericultural States or it may just be a sub-division of entomology division in other States. In addition to research and teaching at a higher level, it would be essential to start courses of training for middle level workers. Short term in-service training for junior cadres of government officials and familiarisation courses for the sake of farmers and rearers, etc. will have to be arranged by the State Departments of Agriculture. The short term training programmes dealing with industrial aspect may continue to be the responsibility of the sericultural sections of the Industries Departments. The Central Silk Board should continue its training arrangements for all-India activities.

26.5.6 Depending upon the kinds of sericulture which a particular State develops, there will be involvement of various disciplines and organisations and hence some sort of coordination will become necessary even at the State-level. Appropriate committees can be set up in the States for this purpose representing the Departments of Agriculture, Industries and Forest, agricultural university, the Khadi and Village Industries Board, men in private seed business and private farmers, rearers and silk industry. The suggested organisation in States will

not in any way interfere with the functional cooperatives etc. recommended in our Interim Report and referred to earlier in this chapter.

6 SUMMARY OF RECOMMENDATIONS

26.6.1 The recommendations made in this chapter are indicated below :

1. Possibilities of extending sericulture all over the country need to be considered. Extension of *tasar* culture throughout the oak belt of the Himalayas is already engaging attention of the Central Silk Board. The principle which should determine extension of moriculture is that it should not unnecessarily encroach on other kinds of sericulture, e.g. eri and *muga* in Assam or with *tasar* in Chotanagpur and Orissa. However, if certain pockets in these States could be developed profitably for moriculture, encroachment may be allowed as an exception. Keeping this in view, moriculture should be studied for adoption wherever possible in the States of Himachal Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, Gujarat, Maharashtra, Andhra Pradesh, Tamil Nadu and Kerala. Ericulture should be tried in the States of Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. In so far as *muga* culture is concerned, possibility of extending it to all the States of the north-eastern region and introducing it along the west coast extending from Kerala to Konkan has to be examined.

(Paragraphs 26.2.6, 26.3.3, 26.3.6, 26.3.7)

2. Before the different branches of sericulture are extended to new areas, feasibility trials should be conducted both in regard to the insect as well as host plants. Research work will also have to be done to explore as to how best community rearing of mulberry and castor silkworms with air-conditioned facilities can be introduced wherever the weather conditions so necessitate. The State Governments concerned have to render assistance in establishing and running the air-conditioned houses. In the case of castor plant, dual purpose varieties and practices will have to be evolved, which can give good yield of leaf as well as seed. Artificial feeding powder with castor leaf has also to be developed for castorworm as in Japan. The quality of mulberry leaves will also have to be improved. All such research work should be done with the involvement of the agricultural universities of the areas concerned and for this purpose coordinated programmes have to be drawn up by the Central Silk Board and its

research stations in consultation with the universities.

(Paragraphs 26.3.2, 26.3.6, 26.3.7, 26.3.8, 26.1.12)

3. Natural and artificial regeneration of the conventional host plants, e.g. *arjun, sasan, sal* should be encouraged in consolidated blocks by the State Forest Departments in the traditional *tasar* areas of the central parts of the country.

(Paragraph 26.2.5)

4. The Central Silk Board should organise seed multiplication and distribution throughout the country for all the four kinds of silkworms on a common pattern and coordinate the same at the all-India level. In order to maintain the best of stocks, import of exotic strains has to be continued judiciously. Production of P3 seed should be the direct responsibility of the Central Silk Board. Production of P2 seed should be the responsibility of the State Governments. Production of P1 and F1 seed should be left to cooperatives, private organised agencies or individuals. Steps should also be taken by the State Governments to encourage and organise gradually chawkie rearing through private organised agencies or individuals for supply to rearers in the place of eggs. This means an addition of one more stage in the chain of multiplication programme, viz., that of certified chawkie worms. The aim should be to supply only healthy young worms to rearers and not the eggs in the case of all the four kinds of silkworms, viz., mulberry, eri, *tasar* and *muga*.

(Paragraphs 26.4.6, 26.4.9, 26.1.14)

5. There should be an independent silkworm seed and chawkie certification agency set up in every State and that the activities of these agencies should be regulated and coordinated at an apex level by a separate certification wing, to be created for this purpose in the Central Silk Board.

(Paragraphs 26.4.8, 26.4.9)

6. A composite Central Silkworms Seed and Chawkie Act should be passed for the country as a whole.

(Paragraphs 26.4.7, 26.4.9)

7. Sericulture has to come in the folds of agriculture directly if it has to be converted into a fully viable profession. The Departments of Agriculture should deal with sericultural aspects upto the processing stage of cocoons. They should also be responsible for reeling activity if rearers themselves are involved in it, but if the reeling is done without the involvement of rearers, it should come under the Departments of Industries. This pattern should be applicable to all the States with appropriate adjustments in their existing set up.

(Paragraph 26.5.3)

8. Every State should form a committee for coordination among the concerned disciplines and organisations. It should have representatives

from Departments of Agriculture, Industries and Forest, agricultural university, State Board of Khadi & Village Industries, men in private seed business, and private farmers, rearers and silk industry.

(Paragraph 26.5.3)

9. The Central Silk Board should come under the Ministry of Agriculture and Irrigation and be reconstituted with representatives from the States, the ICAR, the Union Ministries of Agriculture and Irrigation, Industrial Development and Commerce (Foreign Trade), all-India Khadi and Village Industries Commission and all-India associations, if any, concerning sericulture seed business, private farmers and rearers, and silk industry. There should also be a small executive panel constituted in the Central Board for speedy implementation of the Board's decisions. The Secretary of the Central Silk Board should preferably be technically qualified and have the status of a Joint Secretary to the Government of India. There is already a provision in the Central Silk Board Act 1948 for the levy of cess on raw silk. Such a cess was not levied due to the poor state of the industry. It can be levied for the benefit of the Board when the industry shows signs of viability.

(Paragraph 26.5.3)

10. The Central Silk Board should continue to have its own institutions, but the ICAR together with its institutions and agricultural universities and the Forest Research Institute, Dehradun, should be suitably drawn in the future research programmes. The sphere and extent of cooperation needed from these organisations may be decided upon by the Central Silk Board through periodic consultations. The Central Silk Board should establish a Central sericulture technological research laboratory.

(Paragraph 26.5.4)

11. The agricultural universities should start research, teaching and extension activities in sericulture. It will be necessary to start a sericulture unit for this purpose. This unit may take the form of a full-fledged division in major sericultural States or it may just be a sub-division of entomology Division in other States.

(Paragraph 26.5.5)

12. There should be arrangements for short term in-services training of junior staff and familiarisation training of farmers and rearers, etc. This work should be the responsibility of the Departments of Agriculture. Industrial aspects of training programmes should be looked after by the sericultural sections of the Departments of Industry. The training institutions which already exist under the Central Silk Board should continue their work for all-India activities.

(Paragraph 26.5.5.)

13. A Raw Silk Price Stabilisation Authority has been set up recently by the Central Silk Board for mulberry sector. It is desirable to extend it to all kinds of silk and sericultural products. This authority will serve as an apex body, but separate corporations may be created for mulberry and non-mulberry silks to implement the policies and programmes chalked out by it. There is need to introduce quality aspects in cocoon transactions and it is hoped that this kind of improvement will be included in the schemes of price stabilisation and raw material banks.

(Paragraphs 26.2.13, 26.2.20)

27

APICULTURE

1 REVIEW

27.1.1 Honeybee is commonly linked up in the mind with honey and wax, but it performs a very important function from the point of view of crop production i.e., pollination. In fact, evolution of bees and of plants they pollinate has exerted reciprocal influence ever since the origin of angiosperms. Available evidence suggests that honeybees have functioned as cross-pollinators extensively on geological time-scale much before the primitive man started domestication of wild edible plants or selection of varieties suited to his own preference. The scout bees have an instinctive faculty to compare and select, within their foraging range of 1 to 2 km, a plant species among many others which yields nectar with relatively higher sugar concentration or pollens with better nutritive value. Having made a particular selection in a particular flowering season, the foragers from a colony get themselves conditioned to the preferred plant and restrict their serial floral visits to it alone during that season. This is known as their floral fidelity, which is not met with in other pollinating insects. Bees may not play such an important role in the case of self-pollinated or wind-pollinated crops, but significant increases in yields can be obtained by harnessing the services of bees in the case of insect-pollinated crops. In achieving better performance of some of the pulses, oilseeds, vegetables, fruits and orchard crops, their role may not be insignificant. Beekeeping has already developed in many advanced countries as an essential component of mixed farming like dairy, poultry and other occupations. The primary object of modern apiculture should be to secure higher crop yields, honey and beeswax will come as a byproduct.

27.1.2 Modern apicultural techniques were introduced in India around the turn of this century by certain pioneers with missionary zeal. Scientific research on honeybees and beekeeping was confined to entomology sections of various agricultural colleges and departments particularly at Coimbatore, Pusa, Delhi, Ludhiana and Jeolikote. The emphasis was on academic aspects like comparative morphology,

anatomy, bionomics and to some extent taxonomy of the Indian honeybees. The Indian Council of Agricultural Research (ICAR) also used to finance some research schemes, but there has been significant progress only in the post-Independence era under the aegis of the Khadi & Village Industries Boards of the Centre and States. The All India Khadi & Village Industries Commission, approves programmes and sanctions grants to various State Khadi & Village Industries Boards, which function as major organs for the development of apiculture in States. Some extension programmes are also sanctioned by the Khadi Commission in favour of some private institutions like Ramakrishna Mission, Gandhi Smarak Nidhi and Shastri Sewa Sangh. The State boards initially implement their extension programmes departmentally through their nucleus staff. After distributing adequate number of bee boxes and training to beekeepers, a band of self reliant beekeepers, is gradually built up. The State board encourages such beekeepers to join together and organise themselves into cooperative societies. Cooperative societies receive grants from the Commission through State boards and implement the programme on their behalf. Some beekeepers' cooperative societies in a State join together to form a federation. The State board is generally responsible for effective coordination, implementation, marketing of honey, etc. There also exists an All India Beekeepers' Association. This activity has helped to provide part-time self-employment to forest tribes and farmers in some areas.

27.1.3 In some States beekeeping is encouraged by a small section in the department of Agriculture or Industry. Some agricultural universities have programmes of research in their entomology divisions. Information about various States is given below :

Jammu & Kashmir . . .	Department of Agriculture has an Apiculture Section (Srinagar).
Himachal Pradesh . . .	Apiculture forms one of the sections under the Department of Agriculture (Kangra) and Himachal Pradesh Agriculture University (Nagrota and Katrain).
Punjab	Punjab Agricultural University, Ludhiana has an Apiculture Section under the Department of Entomology.
Haryana	Haryana Agricultural University, Hissar has a section under the Department of Entomology.
New Delhi	Entomology Division of the Indian Agricultural Research Institute (IARI).

Uttar Pradesh . . .	Department of Agriculture has an Apiculture Section (Jeolikote) with a State Apiculturist. There is also an Apiculture Section at the G.B. Pant Agricultural University, Pantnagar.
Maharashtra	State Village Industries Board has an Apicultural Institute at Mahabaleshwar (Satara).
Karnataka	Department of Industries has an Apiculture Section. It is concerned with developmental and training activities.
Tamil Nadu	A post of bee expert exists in the Department of Industries. Functions are mostly advisory.

The question of effective coordination of the above activities is under the consideration of the ICAR and the Khadi & Village Industries Commission.

27.1.4 A Directorate of Beekeeping has been functioning at Bombay since 1954 under the All India Khadi & Village Industries Board/ Commission. All the research and developmental work pertaining to apiculture is done for the Commission by the Directorate. There are about 70 area-offices located all over India for supervising the implementation of the sanctioned extension programmes. There is also a Central Bee Research Institute working under this Directorate at Poona since 1962. Earlier, it was functioning at Mahabaleshwar since 1952 as an Apicultural Laboratory of the Maharashtra State Board of Khadi & Village Industries. The activities of the Laboratory were extended at its wing in Poona in 1954 with the help of the Khadi Commission. This was converted into a full-fledged Institute, as one finds it now. The Central Bee Research Institute implements the research programme through regional bee research centres and field observation stations. On the basis of needs and priorities, Regional Bee Research Centres have been established at Mercara, Kodiakanal and Kangra. The Apiculture Laboratory at Mahabaleshwar (Maharashtra State Khadi & Village Industries Board) continues to function under the technical supervision of the Central Institute. For work on rockbees, another research centre was established at Indore. During the years 1963—1970, ten field observation stations and three model apiaries were established under the Central Bee Research Institute and the regional bee research centres. Observation stations are situated thus : one each in Kashmir and Himachal Pradesh, six in Karnataka and two in Tamil Nadu. Model apiaries are located one each in Kashmir, Himachal Pradesh and Uttar Pradesh. The experimental and

observation stations also serve the purpose of model apiaries.

27.1.5 Most of the countries utilize only one species of honeybee, viz., *Apis mellifera*, which is popularly known as the Italian bee. A great deal of research work has been done on this bee in western countries. It is indeed a high yielder and, therefore, attention was drawn towards it in India too. Attempts have been made to introduce it in the country since 1920. With the interest of the Punjab Agricultural University, Ludhiana, there is indication that it can now be spread over the north-western parts, specially the hills. However, this bee is highly susceptible to various bee diseases, particularly to acarine disease caused by a mite, mostly met in the north. It carries the danger of infecting the indigenous species, which have been almost free from disease so far. The ICAR has suggested that healthy, well tested and established colonies of *mellifera* from Ludhiana could be first tried for their merits and demerits in an offshore island like the Andamans under expert supervision. But the experiment should be preceded by a survey of the extent of occurrence of the indigenous species (*Apis indica*) in order to avoid any chance of its infection. The ICAR's cautious approach in regard to the introduction of an exotic breed is desirable, as the country possesses species with promising potential.

27.1.6 India and adjacent countries constitute the primary centre of origin and evolution of honey bees with maximum concentration and diversity of biological forms. There are as many as 4 species of honeybees (*Apis indica, A. dorsata, A. florea* and *Trigona sp.*) and a few other related Hymenoptera in India. These are briefly described below :

(i) *Apis indica*—It is the only species of Indian bees which can be reared at present in modern portable bee boxes in apiaries. It is also a good pollinator. This bee builds a number of parallel combs in dark enclosures of trees and rock cavities.

(ii) *Apis dorsata* (also known as the Giant rockbee)—It is ferocious, migratory in habit and builds nests high up in inaccessible positions. The nest is in the form of a large single comb well exposed to light. The bee is a very efficient crop pollinator and the best yielder of honey and wax. However, because of its stinging habit, bee hunters mercilessly destroy it in their quest for honey and wax. Attempts are being made to domesticate this species.

(iii) *Apis florea*—It is smaller in size and builds a small single comb exposed to light. It also yields very meagre quantity of honey, but the wax is of a high quality. These

bees also pollinate crop plants with small inconspicuous flowers. It has been observed that, under hot tropical or sub-tropical conditions, the role of *Apis florea* as pollinator is very significant.

(iv) *Trigona sp.*—It is stingless and constructs nest upon trees, rocks or walls. The honey yield is very meagre. Its wax is of inferior quality, but the bee has a special utility in pollination, because it usually visits very small and inconspicuous flowers normally ignored or rarely visited by many other bees or insects.

27.1.7 All the four species of bees found in India are useful in pollination. Each one has some peculiarity, and has a specific role in pollination. Only *Apis Indica* and *dorsata* are important for honey, but all the four kinds are destroyed in search for honey. Destruction is caused because honey gathering here is still by and large a primitive trait which involves burning or destroying bees in their natural habitat, plucking and squeezing nests together with the brood. Modern apiaries established with *Apis Indica* are getting popular, but the pace is slow. There is need to harness the bee fauna of the country to the best advantage both for honey and for increasing crop production. The Central Bee Research Institute at Poona has been making endeavours in this regard by conducting researches on various aspects, e.g. comparative studies on Indian honey bees, bee botany, melitto-palynology (Pollen studies as related to honeybees), pollination of crops, cytogenetics and breeding of bees, bee pathology, pests and predators, problems of rockbees, bee management, chemistry of bee products, honey processing and extraction and purification of beeswax and techniques of manufacturing good quality comb foundation sheets. The institute has standardised techniques for rearing of pedigree queens. The laboratory now produces about 1,500 tested pedigree queens every year. Some other directions of useful research include multiplication of useful bee plants, particularly those flowering in dearth periods for improving bee forage. In order to enrich the existing flora, useful bee plants are introduced from other ecologically homologous regions in the country or even from other countries. An excellent bee plant from Brazil, Ocnistus arborescens, was introduced in Mahabaleshwar plateau around 1960. This plant proved so useful that local beekeepers voluntarily propagated it in their apiary yards. Besides this, experiments to secure annual flowering of some valuable bee plants which flower in nature with intervals of 4, 8, 12, or 16 years have been successfully undertaken at Mahabaleshwar. Then, floral sources of various honeys and the intensity and duration of availability of pollen and nectar from various plants have also engaged attention.

27.1.8 Efforts have also been directed towards domesticating *Apis*

dorsata the rockbee. A Regional Rockbee Research Centre devoted to the research on rockbees was established in 1963 at Indore. Since its establishment, studies on over 1700 colonies were made and observations were recorded on the behaviour of the bees as regards their preferences in selecting nesting sites, location, height above ground level, direction of the comb in relation to north-south bearing, swarming, migration, foraging etc. Detailed studies on comb dimensions at various levels volume of brood, queen and honey cells, body size, etc. were made which helped in designing special equipment for capturing colonies, attracting new swarms to desired places and for collecting honey. A wooden hive was designed which included a brood-chamber and super-chamber. The size of brood frame can be adjusted according to the size of the colony. Five rockbee colonies were hived during 1972 and maintained for over three months at ground level. The success of large scale experiments on hiving, migration and establishment of rockbee apiaries, will bring about remarkable improvement in the honey industry and in harnessing them to increase crop yield through their service in cross-pollination.

27.1.9 The programme of extending modern apiculture is being carried out by 1000 trained extension workers of the Khadi and Village Industries Commission. Bee boxes distributed to beekeepers at subsidised rates or loans during the last 20 years are about 0.5 million. Other statistics on the growth of beekeeping industry from 1953 to 1971 are indicated in Table 27.1. The Statewise position with regard to the development in beekeeping industry for the latest year 1971-72 is indicated in Appendix 27.1.

TABLE 27.1

Progress in Beekeeping under the All India Khadi & Village Industries Commission

Year	Number of bee-keepers (in '000)	Number of colonies (in '000)	Honey production (tonnes)	Average annual honey yield per colony (kg)
1953-54	0.2	0.8	1.3	1.6
1955-56	5	17	23	1.4
1960-61	42	123	434	3.5
1965-66	74	238	1,140	4.8
1970-71	132	451	2,188	4.9
1971-72	138	487	2,275	4.7

The All India Khadi and Village Industries Commission had started with an organisation of about 200 beekeepers in 1953 and by 1971 the number of beekeepers would be about 140,000. The number of villages covered by organised beekeeping is around 30,000. Excluding a part of the harvest retained by the beekeepers themselves, the bulk of honey that enters into the organised market now amounts to about 2,300 tonnes valued at about Rs. 1.5 crores annually. In States like Kerala, Tamil Nadu, Karnataka and Maharashtra, progressive beekeepers have organised themselves into about 100 cooperative societies, some of which are functioning effectively in procuring, storing, processing, packing and marketing of honey and beeswax. There are also organisations for the manufacture of bee boxes and other equipment.

27.1.10 The Central Bee Research Institute of the Khadi and Village Industries Commission also took up the problem of quality control of honey with the Indian Standards Institution and Agmark organisation. Purity specifications and grades for honeys have been now indicated. The Khadi and Village Industries Commission insists on marketing of honey under Agmark certification by the societies. Breeding of bees and their supply to beekeepers is undertaken mainly by the Central Bee Research Institute and to that extent it is a safeguard as far as the quality of bees is concerned.

27.1.11 In the field of training in beekeeping, the Khadi Commission initiated the training of fieldmen in order to create a cadre of field staff, who would be in a position to train the beekeepers at their doors in the various aspects of bee management. This training is given through the local institutions which implement the beekeeping programme. About 1970 fieldmen have been trained so far and these are all absorbed in the industry. At the higher level, there is a training programme for a technical and supervisory cadre of apiarists. This course is conducted at the Central Bee Research Institute, Poona. So far, 102 apiarists have been trained and majority of them are working with the Khadi Commission and the state boards, etc. In fact, it is these apiarists who train the fieldmen. A diploma course at the post-graduate level is also going to be introduced at the Central Institute.

2 SCOPE FOR INCREASING HONEY YIELDS THROUGH ORGANISED APICULTURE

27.2.1 The country's reported production of honey stood at 2,300 tonnes in 1971-72. Some quantity of honey harvested and

consumed in rural areas goes unreported. Every household consumes some honey. Grocers, *hakims*, *vaids* and chemists also have their own stock. All this stock comes directly from the village huntsmen. This honey is crude and impure. If huntsmen of every village contribute 3 kgs per annum, the total quantity from all the villages will amount to about 1,700 tonnes. Thus, the total supply can be estimated at 4,000 tonnes, 2,300 tonnes of reported honey plus 1,700 tonnes (in round figures) of unreported honey. A comparative statement of honey production and per capita availability of honey in India and a few other countries is given in Table 27.2. Honey was known to be abundant in the country, but India is at present at the bottom rung in regard to overall production. Even an arid country like Israel has more production of honey than India. The annual per capita availability is only 7 gms. even if the unreported honey is taken into consideration. This is sufficient to indicate the need for increasing honey production in the country. The only question that remains is as to what extent it is possible to effect such an increase on practical considerations.

TABLE 27.2

Comparative Statement of Honey production and per capita availability of Honey in India and a few other Countries

Country	Year	Population (millions)	Production (tonnes)	Annual per capita availability (gms)
Canada	1970	21	23,360	1112
U.S.A.	1971	207	92,109	445
Argentina	1971	24	20,000	833
USSR	1968	238	222,000	933
Israel	1971	3	1,880	627
Japan	1971	105	8,000	76
India	1971	548	2,275	4

Notes : 1. 1971—Population figures taken from the UN Demographic Year Book.

2. 1971—Production figures taken from the Bee World, 53 : 1972 and for the USSR from Apiacta, 1970 and Proceedings of the International Agricultural Conference.

3. India : If Production is taken @ 4000 tonnes considering the unrecorded honey also, the the per capita consumption will come to 7 gms.

27.2.2 The existing facts on the basis of Table 27.1, Appendix 27.1 and 27.2 are :

(i) villages covered	30,000
(ii) number of colonies	500,000
(iii) average colonies per village	16
(iv) number of beekeepers	140,000
(v) colonies per beekeeper (average between 1953 and 1972)	3
(vi) honey production (tonnes)	2,300
(vii) honey per colony (kg)	5

Only 5 per cent of the villages are covered so far. If all the villages have to be covered and colonies per village are taken at the existing rate of 16, the total number of colonies needed will be 9.2 million. Keeping a margin for death and destruction in handling in transit etc., the requirement of queenbees might be kept at 10 millions. At present, only one station, viz., the Central Bee Research Institute at Poona produces these pedigree queens @ 1,500 per year. Calculating even at a rate of 2,000 queens per year per station, the number of stations, which will be needed for breeding and multiplication, will be 200, provided the full capacity is planned in a total span of 25 years ending 2000 AD. The existing number of stations roughly gives a distribution of 1 per 50,000 villages. Even if this distribution is proposed to be improved to a level of 1 per 5,000 villages, the number of stations required will be approximately 120. Assuming the lower estimate of 120 it would mean a production of $120 \times 25 \times 2000 = 6$ million queens in 25 years and accordingly the target for colonies can also be kept the same.

27.2.3 The honey yield per colony is 5 kgs at present. As technology develops gradually, a doubling of this yield will certainly be possible by 2000 AD. The production will then stand at 60,000 tonnes, which means an increase of 2,400 tonnes per year up to a period of 25 years. At present also, the annual production capacity is of the same order but it has been built up in the course of the past 20 years. In other words, the equipment and organisation that have been built up in 20 years, will have to be added each year hereafter. It is going to be an enormous task. A few components of this task are considered below :

(i) A provision will have to be made for 6 million bee boxes with a few spare ones. It means a production of 240,000 boxes per year or even more spread over a period of 25 years. If 50 boxes are prepared by an artisan in a year, it will mean an employment of about 5,000 men. Comb

foundation sheets will also be needed to be manufactured for each hive. It may mean employment of an equal number of men.

(ii) Taking the present rate of 3 colonies per beekeeper, 6 million colonies will mean the drawing in of 2 million apiary men compared to the existing number of 0.14 million. It would involve developing an organisation to meet the needs of men 14 times more than the present level.

(iii) The country's honey production will go up by about 25 times by 2000 AD. The handling, processing and marketing of this quantity of honey and byproducts like beeswax, royal jelly and bee venom to such an extent will need a great deal of more attention. The manufacture of production, handling and testing tools and pasteurisers for such a large quantity of honey will also need tremendous efforts and involve substantial manpower.

(iv) Honey houses, where honey is tested, processed, bottled and stored, will also need to be established. In Chapter 56 on Marketing Transport and Storage, we have proposed the development of 30,000 markets by 2000 AD. This will imply an average distribution of 10 markets per *taluk*. It will be easy to collect honey from villages and bring to taluks for processing, etc. at these market Centres. Equating with taluks, there will be 3,000 honey houses and considering the total quantity of honey of 60,000 tonnes, each will have to handle 20 tonnes of honey annually which seems to be a reasonably viable capacity. In practice, each honey house should cater to an area which has a minimum output of 20 tonnes of honey per annum. If each honey house has 5 permanent employees, the total number of persons employed will be 15,000.

27.2.4 Apiaries are mostly developed within or in close proximity of forests or over hills, which are rich in vegetation. Natural vegetation generally blooms in the months of February-May. Flowers are not so abundant in other months. Thus, feeding of bees in apiaries all round the year becomes a problem. Although sometimes artificial feeding is resorted to on jaggery or molasses, this is not an answer to the problem. Population of bees does dwindle in lean seasons. In order to obviate this difficulty, migration of bees to agricultural lands in times of crop flowering is accepted as a feasible and workable proposition. Of the three agricultural seasons, comparatively less number of crops grow in Zaid, specially vegetables (mostly

cucurbits). During *kharif* and *rabi* seasons wide varieties of fruits, vegetables and field crops are in flowers between July and February. Therefore, migration of bees can be profitably resorted to from forests to fields in the monsoon season or thereafter. Thus far, the problem of bee forage has not been felt acutely because the number of bee colonies in organised apiculture has built up gradually. As the bee colonies are planned to be increased by twelve times, the problem of bee forage will become acute. Migration of bees will have to be organised. Although some trials in this regard have been successfully undertaken between the Mahabaleshwar hills and adjoining agricultural lands, organisation, transport and equipment will have to be developed for this purpose on a large scale. This will be a new venture of considerable magnitude.

27.2.5 Although the target of 6 million colonies might appear to be too modest, it will be difficult to achieve more, with the existing facilities. However, even the modest target will produce a perceptible impact on production and consumption trends of honey. Population in 2001 AD is estimated to be 945 millions. Sixty thousand tonnes of honey coming from 6 million colonies will mean an annual per capita availability of 63 gms of honey. This does not include honey from natural source, which will increase markedly for reasons indicated in the next section. The two sources put together will increase the per capita consumption much above the stipulated levels. Thus, a tremendous improvement over the existing situation will occur even with the modest target which we have set forth in this section and it is well worth giving a trial to begin with. The question of aiding crop production through pollination is examined in the next section.

3 INDUCTION OF APICULTURE AS AN ORGANISED ACTIVITY TO THE BENEFIT OF CROP PRODUCTION

27.3.1 Estimates of augmented crop yields due to their pollination by honeybees were made at Poona and Mahabaleshwar between 1958-59 and 1960-61. Increases in fruit or seed setting due to bee-pollination were measured over self-pollination in well laid out experiments. Such increases (as percentages of self-pollinated crop) were found to be as follows[1]: coffee 83; niger 173; onion 157, 178; brinjal 35, 67; mosambi 36, 337 and 750; grape fruit 35, 52; orange 471, 900; strawberry 38, 68; guava 70, 140. There is a good lot of data from abroad in this respect. A cross section of such data collected from

1 Single figure against a crop represents the average. If variation between years is large, values for different years have been given as such.

a number of sources is summarised below[1] :

Legume seeds : alfalfa 23.4 to 19,733.3; berseem and other clovers 23.4 to 33, 150; vetches 39 to 20,000; broad beans 6.8 to 90.1; dwarf beans 2.8 to 20.7; kidney beans 500 to 600; runner beans 20.6 to 1,100.

Oilseeds : white mustard 128.1 to 151.8; rai 18.4; rape 12.8 to 139.3; toria 66 to 220; sarson 222; safflower 4.2 to 114.3; linseed 1.7 to 40; niger 16.7; sunflower 21 to 3,400.

Vegetable crops for seed/fruits : radish 22 to 100; cabbage 100 to 300; turnip 100 to 125; carrot 9.1 to 135.4; onion 353.5 to 9,878.

Orchard crops : apple varieties 180 to 6,950; pears 240 to 6,014; plums 6.7 to 2,739; cherry 56.1 to 1,000; strawberry 17.4 to 91.9; raspberry 291.3 to 462.5; persimmon 20.8; *litchi* 4,538 to 10,246; citrus varieties 7 to 233.3; grapes 756.4 to 6,700; cucumbers 21.1 to 411; squashes 771.4 to 800.

Miscellaneous crops : American cotton 5 to 20; Egyptian cotton 16 to 24; buckwheat 62.5; coffee 16.7 to 39.

27.3.2 There are wide fluctuations in increases. Such increases represent varietal differences in self-sterility. In highly self-sterile varieties, there may be practically no seed-setting at all under self-pollination, which apparently amplifies the increase due to cross-pollination to high values. Therefore, the actually reported figures for per cent increase in yield of 'bee-pollinated' as against 'self-pollinated' situations should be duly understood against the background of varietal differences in self-sterility. If these varieties give some seed without deliberately keeping honeybee colonies, it is always due to presence of natural bee colonies or other insect pollinators in the locality. These data positively indicate the possibilities of enhancing yields in the case of highly cross-fertilized or particularly self-sterile crops, which are obliged to depend on bees for their cross fertilization. The data further indicate conspicuous varietal differences in self-sterility with corresponding differences in their increased yields due to bee-pollination. This consideration assumes special importance particularly while planning fruit orchards so as to provide adequate relative locations for self-sterile and cross-compatible varieties to maximise there yields by bee-pollination. In the case of fruit and orchard crops, bee-pollination may also improve the quality of fruits due to the effect of pollen grains on the embryonic and/or maternal tissues. Such effects have been observed in the course of experiments conducted at the Central Bee Research Institute on pomegranates and grapes. In the case of

1 All values are percentage increases over self-pollinated controls.

crops which have varying degrees of self-sterility, any amount of fertilisers, irrigation or cultural care may not give even a fraction of their potential yields unless bees are provided during the flowering period. Examples of such crops are mustard, *gingelly*, niger, safflower, clover, alfalfa (lucerne), cucurbits, almonds or most of the pomacious fruits.

Magnitude of Apiculture in relation to Crops

27.3.3 In order to give an idea of the area under insect-pollinated crops in the country, averages based on the statistics for 7 years (1965-66 to 1971-72) are given below:

crop	area (M ha)
gram	7.9
pigeon pees	2.6
other pulses	11.8
groundnut	7.3
castor seed	0.4
sesamum	2.5
linseed	1.8
mustard	3.1
safflower	0.5
cotton	7.8
jute	0.8
mesta	0.3
sannhemp	0.2
tobacco	0.4
fruits	1.7
vegetables	1.6
total	50.7

Thus nearly one-third of the total cropped area in the country is under insect-pollinated crops, where bees have a great role to play. The number of average sized bee colonies needed for effective pollination ranges from 3 to 9 per ha depending upon floral density and peculiarities of floral biology of individual crops. Taking even the minimum value of 3 colonies per ha, the total number of bee colonies needed for crop production in India will be 150 million. The number of colonies in apiaries is at present only half-a-million and we have tentatively placed the target at 6 million by 2000 AD in the previous section. This covers 2 million ha of the area under crops. On the other

hand nature is full of bee fauna and it is this source which can effectively serve such a colossal expanse of crop area as 50 M ha provided that measures are taken to conserve and proliferate it properly. There does not seem to be any alternative to this course; as there is no prospect of man-managed apiaries in the foreseeable future.

27.3.4 The Central Bee Research Institute has formulated a code of conduct for beekeepers which has been accepted by the Indian Standards Institution as "Code of Conservation and Maintenance of Honey Bees". The main elements of the Code are : registration of beekeepers, hiving in bee boxes, apiary management, modes of migration, regulation of pre-flow build up in colonies, points which should be kept in view the moment nectar starts flowing in the hives, methods of extraction and storage of honey, pooling, processing, testing and packing of honey, extraction and storage of beeswax, hints to utilise bees for pollination and conservation of bee flora. This code, if followed scrupulously, can go a long way in protecting and multiplying the bees and thus help to restore and maintain the ecological balance in local environments. This code is educative and persuasive in nature. While it gives a good base for a start, a massive extension programme will have to be undertaken to educate the tribes which are in the profession of beehunting. They have to be educated not to destroy bees while hunting for honey and wax.

27.3.5 In order to encourage the multiplication of bee colonies in Nature, natural flora will have to be developed all around. A detailed survey of the vegetation of forests and other areas with regard to its floristic composition is required to be done. One has to evaluate the utility of local flora to bees as nectar or pollen sources. Floral calendars giving the flowering period and duration of useful bee plants have to be prepared for each locality. Efforts have also to be made to introduce from various countries bee plants of proven utility to enrich the bee forage and fill up floral gaps. Some local surveys have already been done for the Mahabaleshwar hills. Similar surveys have been extended to Kodaikanal in Palni hills and Coorg and Castle Rock in Karnataka, Himachal Pradesh and Jammu and Kashmir, but such work is required to be extended to all parts of the country. There has to be a general awakening for growing flowering plants in all kinds of spaces, wherever it is possible to do so. It has to be specially done in and around all villages and waste lands. We have visualised to put about one hectare of land per village on an average under floriculture. This should prove useful in the present context. There are also some other problems of bee management which equally deserve attention before bees could be profitably utilised for improving crop yields. These are described in the succeeding paragraphs.

Plant Breeding and Bee Breeding for Improved Crop Yields

27.3.6 A plant breeder, while improving bee-pollinated crops, rarely tries to make the new variety more attractive to bees by deliberately selecting variants with floral nectars having better sugar concentration and composition in terms of various sugars, amino-acids, minerals and other nutrients or pollens with higher palatability, quantity, accessibility and nutritive value for bees. He can certainly include these objectives in addition to other criteria while tailoring the new varieties for higher yields. Significance of this approach can be illustrated by taking the case of clover. Clover (*Trifolium* sp.) is a crop commonly taken in the USA. Being highly self-sterile, it necessarily depends on pollination by honeybees or bumble bees for seed setting. However, most of the clover varieties have very long corolla tubes, at the base of which nectaries are situated. The average length of proboscis or the effective tongue-reach of bees makes it difficult for them to reach such deep seated nectaries. This correspondingly reduces their power of cross-pollination and seed setting in effect may become less than one-tenth the potential seed yield that can actually be realised under optimum effective cross-pollination. This suggests two possible alternatives : breed varieties of clover with corolla tube shorter than the average tongue-reach of local bees, or breed improved strains of local bees with longer tongue-reach so as to pollinate a wider range of plant species with long corolla tubes. Some of the clover breeders have actually succeeded in evolving clover strains with shorter corolla tubes which do give higher seed yield by attracting bee-pollinators to a great extent. As an example of the second approach, the Indian workers have actually succeeded in evolving improved strains of bees with longer* tongue-reach through recurrent mass selection out of the local bee population at Mahabaleshwar. Similarly, larger body size enables bees to harvest more nectar pollen per unit flight. Therefore, longer tongue-reach and bigger body-size can be considered as components among several characters, which collectively subscribe to higher honey yield as well as better pollinating ability leading ultimately to higher seed yield in crop plants.

Protection of Bees against Pesticides

27.3.7 Agronomic operational schedules hardly show any awareness for obligatory provision of optimum bee population during flowering periods of such crops. On the contrary, spray of pesticides is extended even during flowering period of such crops so as to exclude or destroy even the natural population of pollinators in a given

* From its original value of 5.13 mm in 1955-56 to 5.51 mm in 1970-71.

locality. It may be true that application of pesticides becomes unavoidable, but this can be adjusted in such a manner that a period of about a fortnight before flowering and about a fortnight after floral peak is avoided. One can combine the advantages of pesticides as well as of bees through such an adjustment. In several countries, farmers enter into agreement with beekeepers stipulating provisions of optimum number of bee colonies per unit area of their crops. There is a mutual agreement not to use pesticides during the flowering period. In addition, various alternative methods for insect control are being tried in other countries which, if successful, would reduce the use of insecticides. These include biological control by introducing insect predators or other pathogens specific to pests, trapping the pests with the help of insect attractants, introduction of genes for sterility in the natural population of insects etc. There is also a new concept of controlling insect pests on crops by using juvenile hormones effective against specific target species only. This will give ideal protection to bees while controlling individual pests. There is no possibility of insect pests developing genetic resistance against this particular class of target-insecticides. In many countries, manufacturers of insecticides have switched their attention to these new kinds to substitute their old products within a few years. Such materials and methods require the attention of Indian scientists.

Future Action

27.3.8 Two clear-cut directions of development of apiculture emerge from the foregoing discussion. One relates to the establishment of modern apiaries and the other to the protection and proliferation to maximum possible extent of the natural bee fauna including all the four kinds of honey bees. A list of jobs that lie ahead is indicated below :

(i) establishment of 6 million bee colonies covering all villages at an average rate of about 10 colonies per village ;

(ii) establishment of 125 queenbee multiplication stations distributed over all the States and Union Territories. It will be desirable to associate recognised beekeeper's co-operative societies and progressive beekeepers in the multiplication work, but the responsibility of supplying pedigree queens will be that of the stations concerned and, therefore, no separate certification agency will be required ;

(iii) establishment of about 3,000 honey houses for collecting, testing, processing, bottling and storing honey distributed in such a way that each is in a position to deal with about 20 tonnes of honey annually ;

(iv) arrangements for the manufacture of equipment for apiaries and honey houses according to ISI specifications ;

(v) popularisation and enforcement of the use of Agmark honey and honey products ;

(vi) arrangement for migration of domesticated bees (in bee boxes) from forests to fields and vice versa ;

(vii) popularisation of the ISI Code of Conservation and Maintenance of Honeybees for protecting and multiplying their stock in nature ;

(viii) breeding mutually compatible varieties of bees and crop plants ;

(ix) use of such materials and methods of plant protection least harmful to bees ;

(x) laying down agronomic and plant protection schedules favourable to the survival of bees ;

(xi) survey of vegetation of forests and other areas with regard to its floristic composition. Preparation of floral calendars giving the flowering season and duration for different regions ;

(xii) taking steps to plan vegetation in such a manner as to make available suitable flowers for as long a period in a year as possible ; and

(xiii) introduction of plants of proven utility to bees from other countries.

27.3.9 The All India Khadi and Village Industries Commission and the State boards have done a great service in establishing apiaries and organising beekeepers. The Commission has developed a well coordinated system of production, collection and marketing of honey and organised the needed research work. The Khadi Commission should be fully utilised in the jobs indicated in (i), (iii), (iv) and (vi) above. Jobs (v), (vii), (ix) and (x) will need the full cooperation of the Departments of Agriculture, whereas those under (xii) and (xiii) would need cooperation both from the Departments of Agriculture and/or Horticulture and Forests. Forest Departments can play a significant role in the protection of honeybees in their areas. The Departments of Agriculture at the Centre and States will have to take greater interest in apiculture. They will have to participate with or support the Khadi Commission in all the developmental and extension activities up to the village level. Jobs (ii), (viii) and even (ix) to (xiii) involve research. The researches pertaining to honeybee, bee flora and honey technology have been done in a concerted manner chiefly by the Central Bee Research Institute of the Khadi Commission. The agricultural universities will have to participate more actively in the task. Research education and training needs will

increase and it will be useful to include a section on apiculture in the entomology divisions of the agricultural universities. Other disciplines in the universities like plant breeding and agronomy should take care of the concerned aspects.

27.3.10 The status and activities of the Central Bee Research Institute, Poona, will have to be enhanced and the Institute should be developed as a primary national centre for honey and honeybee research and training. It should be treated on par with the other Central institutes of the ICAR and the necessary funds and facilities should be placed at its disposal. How this Institute should be administered could be decided by mutual discussions between the ICAR and the Khadi Commission. Also, the Central Bee Research Institute and the agricultural universities should develop an understanding in regard to their respective work programme. The queenbee multiplication stations in every State could be attached with the universities, but the facilities should also be available to the Central Institute which should exercise full control on the methods and quality of queenbee production. The Forest Research Institute, Dehradun should be associated with researches in forest vegetation. It will indicate specifically the type of vegetation from the point of view of bee fauna in different types of forests including the lands which are going to be put under social and production forestry and road-side plantations.

27.3.11 A committee for policy and coordination should be formed in every State representing the agricultural university, Departments of Agriculture, Horticulture and Forest, the Khadi and Village Industries Board and private beekeepers or their cooperatives. There should be a central committee consisting of representatives from the ICAR, Union Ministry of Agriculture and Irrigation, Forest Research Institute, Dehradun, Khadi and Village Industries Commission, State committees and All-India Beekeepers' Association.

4 SUMMARY OF RECOMMENDATIONS

27.4.1 The main recommendations made in this chapter are summarised below :

1. Apiculture is proposed to be extended to every village. Six million bee colonies are to be developed in modern apiaries at an average rate of 10 colonies per village. Present annual yield of honey of about 5 kg. per colony is to be developed by developing and harnessing bee fauna both for honey and crop production. While this will be achieved through research on all species of honeybee, special emphasis is to be given to the domestication of rockbee, whose

yield potential is very high. There should be no haste to introduce exotic breeds unless it has been fully ascertained and ensured that their popularisation would mean no harm to indigenous species through diseases etc.

(Paragraphs 27.2.2, 27.2.3, 27.1.5, 27.1.7 and 27.1.8)

2. The impact of man-made apiaries on crop production will be by itself very insufficient unless the natural fauna of honeybees is also fully utilised. For this purpose, all possible efforts have to be made to protect and multiply natural bee fauna.

(Paragraphs 27.3.3 and 27.3.4)

3. The infrastructure and expertise available with the All India Khadi & Village Industries Commission and similar State boards have to be fully utilised for the production, collection and marketing of honey and honey products. However, the Departments of Agriculture at the Centre and States have to participate with or support fully the Khadi Commission in all the developmental and extension activities relating to apiculture. They should introduce this activity in their set-up. The Departments of Horticulture (wherever they exist separately from Agriculture) and those of Forests will also have to work in collaboration with the Khadi Commission for planning of orchards and forest trees respectively in the interest of bee fauna. Forest Departments have a significant role in the protection of honeybees in the forest areas.

(Paragraph 27.3.9)

4. The Central Bee Research Institute of the Khadi Commission has to be developed both in the fields of research as well as training and given the status of the Central Institute of the ICAR. How to administer this Institute can be decided by mutual discussion between the ICAR and Khadi Commission.

(Paragraph 27.3.10)

5. Besides the Central Bee Research Institute, the agricultural universities will have to strengthen research on the subject. Apiculture education and training needs would also increase in future. For research, education and training, it will be desirable to develop a section on apiculture under the entomology division of every university. The divisions of plant breeding and agronomy should take due interest in the concerned aspects.

(Paragraph 27.3.9)

6. One queenbee multiplication station is required to be established for every 5,000 villages. It is also necessary that such stations associate with their multiplication work, the progressive beekeepers and their recognised cooperative societies whereas these stations could conveniently work under the universities concerned, a working relationship should be established between the Central institute and the

agricultural universities so that the facilities available at the multiplication stations are also available to the Institute and the Institute is also in a position to exercise control on the methods and quality of queenbee production. Participation of Forest Research Institute, Dehradun is also necessary. It could indicate specifically which type of vegetation should be introduced for the bee fauna in different types of forests including the lands which are going to be under social and production forestry and roadside plantations.

(Paragraphs 27.3.3 (ii) and 27.3.10)

7. A committee for policy and coordination should be formed in every State with members representing the agricultural university, Departments of Agriculture, Horticulture and Forests, the Khadi & Village Industries Board and private beekeepers or their cooperatives. A similar committee should be set up at the Centre consisting of representatives of the ICAR, Union Ministry of Agriculture & Irrigation, Forest Research Institute, Dehradun, Khadi & Village Industries Commission, State committees and All-India Beekeepers' Association.

(Paragraph 27.3.11)

APPENDIX 27.1

(Paragraph 27.1.9)

Position of Beekeeping Industry in India (1971-72)

State	Villages covered (in '000)	Beekee-pers (in '000)	Colonies ('000)	Honey (in tonnes)	Value of honey (in '000 rupees)	Average annual honey yield per colony (kg)
Tamil Nadu .	8.0	39	146	767	4,603	5.2
Kerala .	2.0	12	69	402	2,410	5.8
Karnataka .	2.0	23	85	396	2,375	4.6
North-Eastern States	5.0	22	49	195	907	4.0
Bihar . .	2.0	8	35	158	950	4.5
Orissa . .	5.0	13	29	115	689	4.0
West Bengal .	2.0	8	25	107	640	4.3
Andhra Pradesh	1.0	5	18	47	279	2.5
Uttar Pradesh .	1.0	3	12	24	145	2.0
Maharashtra .	0.2	2	6	25	131	4.2
Himachal Pradesh .	0.6	1	7	21	125	3.0
other states etc.	0.4	2	6	18	106	3.0
total .	29.2	138	487	2,275	13,360	4.7

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